Municipal and County Engineering

DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF ALL PUBLIC WORKS

Vol. LXVII NOVEMBER, 1924 No. 5

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Contracts Awarded

ROADS AND STREETS

Ala., Anniston—Houston Constr. Co., Houston, Tex., awarded contract by State Hwy. Com., Montgomery, for 23 miles concrete road from Talladega County line below Oxford to Cherokee Co. line beyond Piedmont, at $600,463.

Ala., Anniston—C. E. Cox and W. T. Taylor, Clanton, Ala., awarded contract to grade 12.14 miles Jacksonville-to-Piedmont Rd., at $74,160.

Ala., Montgomery—State Hwy. Com., let contract for 4 roads: Covington Co., 14.36 miles gravel—Selma to brdg. over Conecuh River near Gantt Co., 2.8 mi. sand clay rd. and approaches, W. A. Taylor, Sylacauga, at $30,360; Perry, Centreville, Stanley and Singer Constr. Co., Lafayette, $97,408; 2 bridges to B. B. Smith, Montgomery, $25,552; bridge and approaches over Chaba River, roadway, including approaches, to Finnel & Toothaker, Tuscaloosa, $28,114; bridge to B. B. Smith, $61,688; Fayette Co., 18½ miles gravel between Fayette and Winnfield, to W. M. Thompson, Fayette, $174,113; concrete bridges, C. E. Thompson, Fayette, $41,574; Shelby Co., 8 mi. Chert-Wilton to Calrea, via Montevallo, C. B. Cox, Clanton, at $107,132.

Cal., Los Angeles—Warren Constr. Co., 2221 E. 25th St., contr. at $94,497 for impvt. of portion of Melrose Ave., 166,330 sq. ft. Warrenite-bitulithic pavement, 81,800 sq. ft. oil and roll, etc.

Cal., Los Angeles—Geo. H. Oswald, 366 E. 58th St., awarded contract for paving portion of Menlo Ave. with asphalt concrete and various types of bitum. base pavement, at $35,257.

Cal., Manhattan Beach—O. U. Miracle, 227 Ave. D, Kedondo Beach, awarded contract by City Trustees at $88,588 for impvt. of Development Company's tract east of Highland to W. Railroad Dr.-Center St. to Neptune Ave. no. and so.; also portions of other streets, involving 5-in. cem. conc. pavement, cem. walks, curbs, etc., at $88,588.

Cal., Pasadena—C. F. Mathews, 221 Braley Bldg., Pasadena, awarded contract for impvt. of Dakota St.-Lincoln Ave. to Arroyo Blvd., at $17,430; Clarence P. Day Corp., Boston Bldg., Pasadena, awarded contract for paving Westgate St.-Lincoln to Forest Aves., at $7,744; W. A. McNally, 517 S. Broadway, Pasadena, awarded contract for underground conduits, etc., in Green St.-Marengo to Hill Aves., at $78,748.

Cal., Sacramento—Giddings & Whyte, Sacramento, awarded contract for highway between Williams and one-half mile west of Fresh Water Creek, at $63,520.

Cal., Santa Barbara—Sam Hunter, 122 W. Valerio St., Santa Barbara, awarded contract for paving Camino Bey Alberto, at $92,481.

Fla., Bartow—Finley Method Co., Jacksonville, awarded contract to build 12 roads totalling 41 miles (hard surface) in Special Rd. & Bridge Dist. 8: 10 mi. bet. Haines City and Polk City; 9 miles through Holly Hill properties in Davenport and 10 lateral roads.

Fla., Titusville—C. F. Lytle, Jacksonville, awarded contract by State Rd. Dept. for about 9 miles concrete on State Rd. No. 4—Welbourne to Proj. 554, at $290,932.

Fla., W. Palm Beach—Palm Beach County Commissioners let contracts for 2 roads: Military Trail-Okeechobee Rd. to West Palm Beach Canal, to McVay-Lindsay Co., Cocoa, at $38,372; system of short roads w. of Delray, to East Coast Constr. Co., at $18,072.

Ga., Atlanta—City let contracts for 13,577 sq. yds. vitrolithic-concrete pavement; 2,800 sq. yds. asphalt paving on repaired macadam base to Sam B. Finley, Jamison & Hallowell and Meador Construction Co., at $33,466.

Idaho, Kellogg—Mohr Constr. Co., Spokane, awarded contract for construction of Pine Creek road at $51,145; C. M. Payne & Co., Realty Bldg., Spokane, contract for work on same rd. at $18,887.

Ill., Springfield—Following contracts let by Dept. Pub. Wks. and Bldgs.: Clinton County pavement to Wabash Constr. Co., Vincennes, Ind., at $41,580; Sangamon Co. pave. to Alzina Constr. Co., Springfield, at $28,945; Menard Co. pave. to McElwee & Rogy, Peoria, Ill. (Old Salem State Pk., at $44,254; Cook Co. pave. to Bjorndahl Construction Co., Arlington Hts., Ill., at $13,128.

Ind., Hammond—Ahlborn & Laverne, Hammond, awarded contract by Board of Works here for 10,560 sq. yds. conc., paving on portion of 19th Ave., at $33,792.

Ind., Indianapolis—American Constr. Co., Indianapolis, awarded contract by Marion County Commission for improvement of Elmer Trester et al. road, WashingtonTwp. Asphalt on concrete base, 3,722 ft. long x. 18 ft. wide. Anti-creeping reinforcement to replace binder course, $25,834.

Ind., Indianapolis—McCoun Constr. Co., Noblesville, Ind., awarded contract by Marion County Rd. Commission for 16,655 sq. yds. concrete pavement on Chas. L. Steinmeier Rd. (or 52nd St.), at $53,476.

Ind., Laporte—Loporte County Commrs. awarded following contracts for road construction: J. Bash Rd., Center Twp., to Gross Constr. Co., Laporte, Ind., at $29,320; Elwood Haun Rd., Center Twp. to same contractor at $57,950; F. J. King & Co., Laporte, contract for Herman Zirzow Rd., Center Twp., at $10,500.

Ind., Sullivan—White Construction Co., Chicago, Ill., awarded contracts by Com. Council for impvt. of Jackson and High Sts. in Sullivan; estimated costs $39,098 and $6,806 respectively.

Ind., Valparaiso—Gerald McGillicuddy, local, awarded contract by Porter Co. Commrs., for construction of Allen Shinbarger Rd., Union Twp. and Wm. Spencer Rd., Pleasant Twp., at $30,900 and $15,800, resp.

Ind., Vincennes—Roscoe Manning, Decker, Ind., awarded contract by Knox County Commission for Obe Charlton et al. rd. in Widney Twp. gravel, 4.278 mi., at $33,290.

Iowa, Marshalltown—Contracts let to following: FAP 211, paving to Anderson and Empie, Marshalltown, earth excav, 65c per c. y.; pave., 73,898.3 sq. yds., $1.98 per sq. yd.; 70,122.8 sq. yds., $2 per sq. yd.; 91,419.8 sq. yds., $1.83 per sq. yd.; single special intakes, $85 each; double special intakes, $100 each; Primary Rd. proj. 240, gravel, to Northwestern Gravel Co., 400 U. B. Bldg., Des Moines, 4,880 c. y., at Marshalltown, $1.52 per c. y., at

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Haverhill, $1.95 per c. y.; 6,000 c. y., at Laurel, $1.85 per c. y. Haul, Powick Constr. Co., 402 Observatory Bldg., Des Moines, 1 mi. haul, 38c per c. y., ½-mi. haul, 8c per unit.

Ia., Orange City—Contracts for road work let to following: Prim. Proj., 223-D, to C. F. Betz, 2023 Nebraska St.,Sioux City; 23,303 c. y. excav., 23.7c; pipe labor, 40 ft., 14 in., 20c, 160 ft., 18 in., 25c; 96 ft., 24 in., 30c; Prim. Rd. Proj. 391-D, to Wielinga & DeHaar, Alton, 4,000 c. y., stripping pit, 18½c c. y.; Vander Schaaf & Vander Stouwe, Hull, 8,088 c. y. gravel, 1 mi. haul, 29c; 90,000 units one-half mile haul, 7¾c per unit.

La., Baton Rouge—C. R. White, Centerville, Miss., awarded contract by State Hwy. Commission, Reymond Bldg., Baton Rouge, for graveling 7.78 miles Greenwall-Springs Rd., E. Baton Rouge Parish, at $48,193.

Md., Baltimore—American Paving & Contracting Co., Montebello Ave., awarded contract by Board of Awards at $60,512 to pave with sheet asphalt 4 streets.

Md., Baltimore—State Rds. Comn., let contracts for 7 roads: Carroll Co., 2 sections; .35 mile to Gosnell-Russell & Co., Frederick, Md., at $89.65; .29 mile to Thomas, Bennett & Hunter, Westminster, Md., at $7,483; Howard Co., .28 mile to Thos. Mullan; Prince George's Co. gravel road to St. Mary's Construction Co., Mechanicsville, Md., at $9,377; Washington Co., 700 ft. macadam rd. and bridge at Sideling Hill; I. C. Robinson, Hancock, Md., $16,000; Wicomico Co., 1.13 mile concrete road between Salisbury and Snow Hill, P. D. Phillips & Bro.; Salisbury, $16,000; Allegany Co., .63 mile concrete on Main St., Tri-State Engrg. Co., Cumberland, Md., at $19,544.

Md., Baltimore—F. D. Carozza Co., Notre Dame Ave., near Whiteford Ave., awarded contract to pave with cement 8 streets in New Annex, at $41,-364.

Md., Baltimore—State Roads Commission let contracts for 2 roads, Charles County: 2.81 mile gravel surf.-end of Cont. Ch-27 to Chicomuxen, to Huse & Knight, Baltimore, at $26,800; Calvert Co., 1.51 miles gravel surfacing-end of Cont. C-15 to Broome's Island, to Thos. Mullan, 3945 Greenmount Ave., Baltimore, at $17,863.

Mich., Lansing—Following contracts authorized at meeting of State Administrative Board: 4.046, 18-ft. concrete F A P, M-11, Benzie Co. to L. I. Goldberg, Scottville, at $28,513 per mile, unit prices being 48c for excav. and $1.44 for 6-in. stand. concrete surfacing; Clifford Bridges, Norway, Mich., contract for 4,451 miles Cl. A., 16-ft. gravel on M-28-9, B-1, Baraga Co. at $4,630 for surfacing only; John J. Bacco, Marquette, contract for 4.434 miles same type of surfacing, Sec. B-2 on M-28-9, B-2 on same rte., at $5,983.43 per mile; grading on both these projects has already been completed and the contracts are for surfacing only.

Minn., Duluth—C. R. McLean, awarded contract for impvt. of Wabash St., Allendale to Maxwell Aves., at $31,087.

Miss, Bay St. Louis—Minder & Cain, Mankato, Minn., awarded contract by State Hwy. Dept., Jackson, to grade, drain and gravel surf., 18 miles between Bay St. Louis, Hancock, County and La. State line, at $219,000.

Miss, Mayersville—Hart & Faulkner, Sartartia, Miss., awarded contract at $65,825 for 6½ miles Vicksburg-Rolling Fork Rd., Issaquena Co.; contract let by State Hwy. Dept., Jackson.

Miss., Rolling Fork—H. E. McAdams, Rayville, La., awarded contract by State Hwy. Dept., Jackson, to grade and drain 10 miles Vicksburg-Rolling Fork Rd., Sharkey Co., at $60,000.

Miss., Starkville—Pilkinston Bros., awarded contract by Oktibbehs County Board of Supervisors for 2 roads, at $35,000. Grade and rock 4miles Lower Greensboro Rd.

Miss., Vicksburg—Southern Material & Constr. Co., Little Rock, Ark., awarded contract to pave with 50-ft. conc. roadway, river landing bet. China and Clay Sts., from seawall to ferry landing at ft. of Crawford St. and 26-ft. roadway from landing proper to ferry landing, at $38,610.

Neb., Lincoln—Abel Constr. Co., 318 Terminal Bldg., Lincoln, awarded contract for concrete and asphalt paving in District 576, at $27,057, also contract for grading, paving and curb in Dists. 537 and 541, at $29,287 and $5,712, respectively; Cochrane Constr. Co., 822 First Natl. Bank Bldg, Lincoln, awarded contract for similar work in Dist. 615, at $10,311.

Neb., North Platte—Following contracts let for grading, guard rail and culverts in Lincoln Co. on North Platte-Maywood Project 221-B, 15.5 miles: Grading to Peterson, Shirley & Gunther, 1102 W. O. W. Bldg., Omaha, at $37,540; culverts to Dan Quinton, Kearney, at $4,716; guard rail to Metz Constr. Co., Springfield, at $1,604.

N. Y., New York—H. Bruckner, Pres. Bronx Boro, let following contracts: Grade, curb and constr. walks on Liebig Ave., to Spedero & Turriamo, 3185 E. Tremont Ave., at $9,674; McClellan St. and Rodman Pl., to L. DiMinna, 2366 Lorillard Pl., $2,059 and $1,410, respectively; Barker and Crosby Aves., to Bronx Sewer Constr. Co., 375 E. Fordham Rd., at $3,111 and $18,530, respectively; 212th St. to F. Babrielle, 1129 9th Ave., $3,130; Laconia Ave., to O'Connell & Strada, 3318 Olinville Ave., $28,872; Paulding Ave., to Interboro Asphalt Co., 2306 Creston Ave., $12,929; Yates Ave. to J. V. Timoney Constr. Co., 220 S. 201st St., at $8,387, all grading, curbing and constr. of sidewalks.

N. Y., New York—Asphalt Construction Co., 208 Broadway, awarded contract for granite block repaving on West Third St. and West End Ave., at $31,517 and $42,568, respectively; J. E. Gaffney, 50 E. 42nd St., contract for regulating and sheet asphalt paving on E. 111th St., at $30,970.

N. C., Greensboro—R. G. Lassiter Co., Oxford, awarded contract to hard surface 8 miles roads in Guilford Co., at $90,000.

N. C., Raleigh—R. G. Lassiter Co., Raleigh, awarded contract to pave 80 streets here, at cost of about $1,000,000.

N. C., Yadkinville—State Hwy. Com., at Raleigh, let contract to L. L. Tindall Constr. Co., Waterford, Wis., to hard surf. 10 miles road from Yadkin River to Yadkinville, at $482,528.

Okla., Tulsa—Tulsa County let contract for six 18-ft. concrete roads, bridges and culverts: 1¾ miles from N. line Broken Arrow to Lynn Lane Rd. and 1 mile N. on Lynn Lane Rd. to Highway Const. Co., Tulsa, at $47,025; 1 mile Bixby-Okmulgee, to Bert-Gibbs Co., Tulsa, at $28,250; 3,000 ft. Red Fork-Keystone Rd. to Highway Constr. Co., $15,-000; ¾-mile so. from Klennpol to Dan A. Burton Co., Tulsa, at $16,325; 1 mile from Broken Arrow to cemetery, to Gallamore Constr. Co., Cushing, at $24,638; 1¼ miles from Shell Creek brdh. near Wekiva, west to Shell Creek rd., to Tanner & Co., Tulsa, at $29,950; E. G. Fike Constr. Co., Tulsa, to widen Nickel Creek bridge from 16 to 28 feet near Oakhurst; same contractor at $13,115 for 12 culverts in north end of county.

Texas, Amarillo—R. H. Duncan, awarded contract by Porter County Commrs. Court at $39,000 for 1 mile brk. pavement connecting St. Francis Hwy. with Filmore St., N. Amarillo.

Texas, Brenham—Womack Constr. Co., Sherman, awarded contract by Washington County for 3 secs. of roads: Grade and complete McMillan Contr. 19-15 mi. Brenham-Washington Rd.,$89,516; grade 1.29 miles Gay Hill cut-off road, $7,056; grade and complete .32 mile State Hwy. 20.

Ark., Clarksville—McGuire & Cavender awarded contract for 18-ft. conc. pavement on 2.66 miles State Hwy. No. 5, east line of Road Dist. 9 to Lamar Co. line, approx. cost $180,000.

Texas, Hemphill—Austin Bridge Co., 1815 Clarence St., Dallas, awarded contract by Hall County for 11.86 miles atSte Hwy. 18, at $61,135.

Texas, Palo Pinto—Smith Bros., Inc., Dallas, Texas, awarded contract by Palto Pinto Co. at $469,293 for 5 sects. of roads, including 32.15 miles 2-in. amiesite at 14-78 miles 1-in. inverted penetration.

Texas, San Antonio—Colglazier & Hoff, San Antonio, awarded contract to pave with asphalt 8.16 miles Seguin Rd., at $110,610 (Bexar County.)

W. Va., Charleston—Fayetteville Constr. Co., awarded contract to surf. 6 miles Dunbar-Sattes Rd., at $67,900; J. O. McDermitt, at $30,026 to grade and surf. with slag base and penetration macadam top, Tyler Mountain Rd., at $30,026, both contracts let by Kanawha Co.

W. Va., Huntington—Duncan & Griffith, awarded contract by City Commission to pave 2 streets with brick on concrete base; Jack Ullom, concrete on one street; J. A. Griffith, 1561 Wash. Ave., brick on concrete base, 1 street; T. E. Walker, 2839 Third Ave., concrete alley; W. E. Graham, 225

Main St., brick on concrete base, 1 street; Geo. Henkle, at $39,519 for Old Cross Rd.

W. Va., Welch—Albert Bros., Shawsville, Va., awarded contract by McDowell County Ct., for road from Coalwood Rd. to town of Coalwood, at $13,295; 2½ miles Ashland-Cherokee Rd. to White, Rich & Co., Princeton, at $23,575; also for 2 bridges at Susanna, to Werraldo & Jauntolo, Welch.

SEWERAGE AND SEWAGE TREATMENT

Ark., Harrison—P. L. Blackshire, Harrison, awarded contract by City Council for installation of sewage system, at $26,295.

Cal., Alhambra—Culjak & Bebek, 425 W. 78th St., Los Angeles, awarded contract for reinf. conc. storm drain in Ramona Blvd., Hellman Ave., and other thoroughfares, at $52,480. Work involves 4,900 ft. 48-in., with 12-ft. to 20-ft. cut with ave. cut of 14-ft., 23 catch basins and laterals from catch basins to main sewer; Cox & Teget, 615 N. Olive St., Alhambra, awarded contract for constr. of sewers in Dist. 11, at $92,916.

Cal., Oakland—M. Smith, 1003 85th Ave., awarded contract for constructing 18,288 lin. ft. 8-in. vit. sewer, 48 manholes, etc., in Fruitvale Garden Farms tract, at approx. $52,000.

Cal., Reedley—Heafey, Moore & McNair, San Francisco, awarded contract at $109,421 for new sewage system after Frederickson & Shannon, low bidders, were relieved of their erroneous bid by city trustees.

Cal., San Bernardino—F. W. Seccombe, 242 E. 4th St., San Bernardino, awarded 4 sewer contracts, using vit. pipe, as folows: Arrowhead Park No. 1 sewer: 4-in. pipe at 50c ft., 8-in. at 58c ft.: manholes, $70 each; flush tanks, $110; 13th St. F to G, 4-in. pipe at 40c ft.; 8-in. pipe at 66c ft.; manholes, $70 each; flush tanks, $110; Hanson St., I to J: 4-in. pipe, 44c ft.; 8-in. pipe, 73c ft.; flush tanks, $110; Magnolia and Florence Aves., 4-in. pipe, 40c ft.; 8-in. pipe, 65c ft.; manholes, $70 each; flush tanks, $110 each.

Ont., Kapuskasing—LaCroix & Caron, local, awarded contract for 2,930 ft. 8-in. and 900 ft. 12-in. vit. glazed tile sewers; also 2,960 ft. water mains in various streets; engineer's est. $30,000.

Ont., Kenora—Kelly & Kimberly, Kenora, awarded contract for 2 miles of sewers; engineer's est. $50,000.

Ont., Port Elgin—W. T. Ellis, R. R. 1, Walkerton, Ont., awarded contract for conc. disposal plant; T. J. McLean, Wingham, Ont., contract for sewers; engineer's est. of cost $35,000.

Ont., Riverside—Merlo, Merlo & Ray, Ford, Ont., awarded contract for sewage disposal plant at $50,000.

Ont., Toronto—Connolly & Agnew, 606 Avenue Rd., awarded general contract for sewers here, at $30,537.

Ont., Toronto—McLaughlin Bros., 55 Gould St., Toronto, awarded contract for 72-in. brick and concrete trunk sewer, open cut and tunnel work, East York Twp., Municipal Yd., Sammon Ave., at $72,800; East York Twp. will build, by day labor, 5,000 ft. 8-12 in. tile san. sewer in Hopedale Ave., $11,000; 12,000 ft. 8-15 in. vit. tile sewer in Gamble and Gowan Aves., $29,000. Supervision of G. R. Jack, Sammon Ave., Twp. Engr.

Ga., Macon—J. B. McCrary, Citizens & Southern Bank Bldg., Atlanta, Ga., awarded contract for building lateral sewers on Cherokee Hts. and laterals adn outfall on Brewery Lane section, at $23,-863.

Iowa, Waterloo—P.Berg, 619 Smith St.,Waterloo, awarded contract for san. and storm sewers, including 9,321 ft. 8-35 in. sewers, 4 stand., bulkheads, 40 lin. ft. 10-in. vit. pipe, etc., at $36,148.

Ind., Hammond—Board of Works let following contracts: Public Constr. Co., Hammond, contract for 23rd St. sewer at $20,380; Ashborn & Lavene, Northcote sewer, at $14,300; Brophy & See, 21st Ave. sewer, $11,841 and A. C. Proudfoot, 25th Ave. sewer, at $13,870, all contractors located in Hammond.

La., Bastrop—James Construction Co., Shreveport, awarded contract for sewage disposal plant and 59,300 ft. 8-24 inch vit. clay sewers in general streets, at $87,371.

Mass., Boston—V. Barletta, awarded contract for sewerage works in Binford St.—A St. to Necco St., etc., at $17,024; M. DeSisto Co., contract for sewerage works in Newfield and LaSalle Sts., at $27.35; John Williams & Co., contract for sewerage works in Stellman Rd., private land, and other streets; W. Rosbury, at $35,414; C. Jacozza, contract for sewerage works in Wilmington Ave.—Capen St. to about 230 ft. east and outlet in Capno St.—FairmountSt. to Wilmington Ave., Dorcester, at $2,945; A. D. Daddario, contract for sewerage works in Ralston Rd., Hyde Park, at $2,962.

Mass., W. Roxbury—(Boston, P. O.)—J. Williams & Co., 58 Wales Pl., Dorchester, awarded contract for sewerage works in Stillman Rd. and private land, at $35,414.

Mich., Detroit—J. Monte, 3049 Russell St., awarded contract by Wayne County Rd. Comn. for 1,350 ft. 72-in. concrete sewer in Warren Ave., at about $25,000.

Minn., Hawley—Hanson & Hermanson, Redwood Falls, awarded contract for sewerage system, at $23,436.

N. Y., St. George—G. Orrico, 500 Britton Ave., Concord, awarded contract by J. A. Lynch, Pres. Richmond Boro., for san. sewers in various streets here, at $89,719.

Ohio—New Philadelphia—H. Schneider, New Philadelphia, awarded contr. for storm sewer in south side, at $39,945.

Ark., Luling—R. J. Estep & Co., Wilson Bldg., awarded contract to construct sewer system and disposal plant, $40,000. Koch & Fowler, engineers, Central Bank Bldg., both Dallas.

Texas, San Antonio—McKenzie Constr. Co., 605 Bedell Bldg., awarded contract for 6,000 ft. storm sewer in Peach St., at $69,247.

Wis., Milwaukee—Milwaukee Struc. Steel Co., Western Plank Rd., awarded contract for furnishing and erecting struct. steel for sludge storage bldg. on Jones Island, at $49,480.

WATER SUPPLY AND PURIFICATION

Ala., Mobile—Federal Constr.Co., Odd Fellows Bldg., St. Louis, Mo., awarded contract to construct water mains, connecting with existing systems, at $90,296.

Ariz., Phoenix—S. Morgan Smith Co., awarded contract for three 15,000 h. p. vertical turbines for the Now Horse Mesa Dam power project; General Electric Co. contract for three 13,250 K V A generators and 117,000 K V A 11,000-volt transformers to be installed at Horse Mesa, Roosevelt, Goldfield, Miami and Superior. Other equipt., including lighting arrestors and switching equipment, amounting to $200,000, also purchased.

Cal., Oxnard—Western Pipe & Steel Co., awarded contract by American Beet Sugar Co.,to furnish casing for wells being drilled. Casing is 16-in. and totals about 200 tons.

Ont., Chippewa—General contract for water works let to Webster Constr. Co., London; pumps to Goldie & McCulloh Co., Ltd., Traders Bank Bldg., Toronto; filters to Canadian International Filter Co., Ltd., Confederation Life Bldg., Toronto; meters to National Meter Co., of Canada, Toronto; 60,000 gal. elevated steel tank to Horton Steel Works, Bridgeburg, Ont.

Que., Three Rivers—B. J. Trepanier, Three Rivers, awarded contract for constr. of 6 bed rapid sand filtration plant, at $314,500.

Ont., Etobicoke, Twp.—Contracts let as follows for water works system: General contr. for laying main to Huffman & Hardwood, Humber Bay, Ont., at $9,888; gate valves to T. McAvity & Sons, Ltd., at $1,043;valve boxes to Drummond, McCall & Co., Ltd., at $462; pipe to National Iron Corp., Ltd., at $25,740; special castings, Dominion Wheel & Foundries, Ltd., at $921.50; hydrants to Bawden Mach. Co., Ltd., $2,680, all Toronto.

Que., St. Joseph d'Alma—Bourassa & Clifford Co., Ltd., St. Antoine St., Three Rivers, awarded contract for complete aquedact sys. by gravity from lake, 14 to 20-in. wood stave pipe, etc., at $225,000.

Md., Baltimore—R. D. Wood & Co., 400 ChestnutSt., Philadelphia, Pa., awarded contract by Mayor and City Council for cast iron pipe and fittings to Water Dept., at $289,696.

Neb., Lincoln—Contracts let as follows for reservoir and equipment: Economizer to Green Fuel Economizer Co., Beacon, N. Y., $13,632; boilers to Murray Iron Wks., Burlington, Ia., $22,950; two-chain gate stokers to Green Engrg. Co., E. Chicago, Ind., at $6,190; 2 super-heaters to Powers

Specialty Co., New York City, at $3,450; 2-soot blowers, Diamond Power Specialty Co., Detroit, Mich., $1,086 reservoir, 5,000,000 gals., capacity, to Knudsen & Co., Lincoln, at $63,000.

N. Y., Long Island City—Norton & Rigney, Richmond Hill, awarded contract by N. J. Hayes, Commr., Municipal Bldg., New York, for mains in various thoroughfares, at $31,000; Melrose Constr. Co., 103 E. 125th St., New York City, awarded contract by Commr. Hayes for water works in various streets, at $46,710 (New York City ; Knight and DeMicco, Inc., 448 E. Tremont Ave., New York City, contract by Commr. Hayes for mains in various streets in Brooklyn, at $8,470.

N. Y., Salamanaca—Mullen, Guianne & Ludwig, Inc., Jamestown, N. Y., awarded contract for construction of new reservoir at Salamanca, N. Y., at $88,320.

N. C., Mt. Holly—W. O. Pratt, Mt. Holly, awarded contract to construct 1,000,000 gal. water purification plant and pipe line extension, total cost $86,000.

Ohio, Cincinnati—M. J. Connelly, Sr., 326 W Oak St., Ludlow, Ky., awarded contract for 26,710 ft. 4-12-inch. cast iron mains in water supply line 4, Dist. 1, Fairfax and Madison Hts., at $54,391; Crumley, Jones & Crumley, 2301 Concord St., contract for 53,415 ft. 4-16-inch cast iron mains in water supply line 2, Dist. 1, Deer Park, at $114,238.

Okla., Seminole—N. S. Sherman Machine & Iron Works, 18 E. Main St., Oklahoma City, awarded contract for new water works system, including well, tank, valves, 3,700 ft. 4 and 3-inch mains, etc., at $39,000.

Wis., Crivitz—General contract and dam for hydro-electric plant and dam on Peshtigo River at Sandstone Rapids between Crivitz and Johnson Falls, let to J. R. McDonald, Black River Falls; equipt. contract to Allis-Chalmers, W. Allis, Milwaukee; about $600,000; to develop 6,000 h. p. Owner, Wisconsin Public Service Corp, Milkaukee.

Prospective Work

ROADS AND STREETS

Ala., Anniston—Chamber of Commerce interested in improving Horse-block Mountain rd. to connect Anniston with sections of Cleburne and Clay Cos.

Ala., Birmingham—State Highway Commission, Montgomery, plans to buld 12 or 13 miles Bankhead Hwy., Irondale to Leads.

Ala., Birmingham—City Commission has authorized concrete paving on 4 streets at $51,200; asphaltic conc. on 3 streets at $24,450.

Ala., Mobile—Mobile County Board of Revenue contemplates 15 miles concrete Hall's Mill Rd., from Government St. loop toward Grand Bay.

Cal., Anaheim—City Mgr. J. W. Price has started proceedings for paving E. 9th St. for more than 1 mile east of city, making Ninth St. a main traffic artery.

Cal., Inglewood—City Council has started proceedings for street improvements amounting to $171,547. City Engr. Arthur W. Cory estimates cost of paving of Oak, Rodondo to Arbor Vitaae, Magnolia Ave., Sprague and Olive Sts., and oiling Cedar and Elm Aves.; also grading Sycamore Ave., at $94,650; paving Arbor Vitae St., Market to Kenwood, is to cost $69,946.; est. on Nectarine St., Eucalyptus to Damask, including oil macadam, curbs, walks, gutters, is 06,951.12.

Cal., Los Angeles—$1,000,000 municipal district bond issue for road from Whittier Blvd. to Pacific Palisades at Santa Ynez canyon carries at recent elec. Edwin Janss is director of the Beverly Blvd.; impvt. assn. backers of the new project.

Cal., Riverside—Proceedings started for a 12 months' street paving program including Third St., Maine to Pine; Second St., Walnut to Pine; First, Walnut to Pine; Houghton Ave., Fairmount to Walnut; Pine, Fourth to Walnut Sts.; Houghton to Pine west to Fairmount Pk.; also portions of Randall Rd., Redwood Dr., paving, walks, curbs, gutters, sewers, etc.

Cal., San Diego—Chamber of Commerce has endorsed a $500,000 bond issue for completion of highway from Julian via Cuyamaca lake to Descanso.

Cal., Seal Beach—City Council has ordered the paving of 5th, 6th and 7th Streets; type not determined, Warren Hillyard, City Engineer.

Fla., W. Palm Beach—Palm Beach Co. Commrs plan extending Ocean Blvd. northward to Jupiter bldg., bridge across Lake Worth inlet and developing road system no. of W. Palm Beach. Election in November to vote on $625,000 bonds.

Idaho, Lewiston—State Hwy. Dept. will call bids within 60 days for constr. of 4 miles Orofino-Ashaka sec. Lewis-Clark Hwy. Est. cost $60,000.

Ia., Fort Dodge—Webster County will carry out following road work in 1925: Drain, grade, gravel Prim. Rd. 16—Gowrie to Green Co., 5 miles; grade and gravel Prim. Rd. 90—Dayton to Boone Co., 4 miles. Total 16 miles. $45,000. C. A. Shook, County Aud.

Ia., Webster City—Hamilton County may let contract within a few weeks for graveling Wilson Hwy.—Blairsburg no. to County line 6 miles. Abt. 1500 yds. gravel to the mile. Work will start early in Spring. Howard Baxter, Aud.

La., Alexandria—Rapides Parish Police Jury plans to hard surf. 20 miles Jefferson Hwy.—Alexandria to Lecompte; probobly brick.

Md., Baltimore—Municipal Dept. of Public Impvts. has approved plans to open street 2 miles in length and 100 ft. wide from Belair Rd. and Erdman Ave. to point on Phila. Rd. Howard W. Jackson, Mayor. Jos. W. Shirley, Chf. Engr. of Survey Comn.

Md., Salisbury—State Roads Commission, 601 Garrett Bldg., Baltimore and Penn. Railroad Co.—A. C. Ehand, Chf. Engr.—Philadelphia, Pa., plan to extend E. Main St., Salisbury under railroad tracks to Ocean City near City limits.

Minn., Bessemer—$55,000 appropriation recommended by Gogebic County Commissioners to resurface 26 miles of Hwy. K-12; macadam surf. on old Co. rd. bet. Ironwood and Bessemer. Also $10,000 appropriation for improving road betw. Ramsay and Wakefield. County Engr. C. F. Winkler; Dist. Engr. H. I. Davies, Escanaba.

Miss., Jackson—Hinds County Board of Supervisors plans to hard surface principal highways. Contemplates $400,000 bond issue.

Mo., Albany—City plans to gravel 8½ miles of streets. $60,000 bonds voted.

Mo., Springfield—City plans to pave Lombard St. —New to Lexington; also Atlantic—Broadway to Kansas.

Neb., Hastings—City may adopt plans to gravel streets outside of paved districts. Considering plan to gravel Laird Ave.—3rd to 7th Sts. A. T. Bratton, Clk.

Neb., Omaha—Ordinances passed for St. Impvt. Districts Nos. 2691, 2689, 2684, 2625, 2692, 2693, 2685, 2688, 2687, 2690, 2686. Paving with asphalt, stone, vit. brk., vit. brk. blk. artif. stone, macadam, creo. wood blk. or asph, conc. Petition filed to widen 25th street 80 ft. instead of 100 ft. Est. cost of widened to 100 ft., $240,000. Jas. P. Hoctor, City Clerk.

Neb., Omaha—Petition made to widen 24th St. —St. Mary Ave. to Harney St. 80 ft. instead of 100 ft. Est. if widened 100 ft. $240,000. Jas. P. Hoctor, City Clk.

Neb., Silver Creek—Plans made for resurfacing all main streets with gravel.

Neb., Tilden—Will grade business and several side streets; pave later. Engrs. Prince-Nixon Engrg. Co. 501 Peters Trust Bldg., Omaha.

N. C., Morehead City—Board of Town Commrs. plans additional street paving. $200,000 bond issue authorized.

N. C., Raleigh—State Hwy. Comn., Raleigh, will improve 3 roads: 7 mi. hard surf. from Moresville to Catawba River; 10 miles to Turnersburgh to Yadkin Co. line and 6 miles Wilkesboro Rd. Est. cost $305,000.

N. C., Raleigh—City plans bldg. and rebuldg. surf. of streets; contemplates $1,500,000 bond issue. W. L. Dowell, Clk.-Secy.

N. Dak., Fargo—Request filed with State Hwy. Dept. for survey, plans and ests. for constr. of 30-mile stretch of road on the Meridian Hwy., Fed. Aid Proj. from Fargo NW thru Harwood, Argusville, Gardner to the Traill Co. line. F. F. Doherty, Co. Aud.

Okla., Miami—State Hwy. Comn. Okla. City, has approved plans for 2½ miles gravel Afton-Vinita

BUYERS' GUIDE

Aerial Tramways.
American Steel & Wire Co.

Air Lift Pumps.
Harris Air Pump Co.

Armor Plates.
Truscon Steel Co.

Asphalt.
Bitoslag Paving Co.
The Barrett Co.
Kentucky Rock Asphalt Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Asphalt Paving Co., The

Asphalt Filler.
The Barrett Co.
Bitoslag Paving Co.
Standard Oil Co. (Indiana)
The Texas Co.
Warren Bros. Co.

Asphalt Floors.
The Barrett Co.
The Texas Co.
Warren Bros. Co.

Asphalt Machinery.
Chausse Oil Burner Co.
Cummer & Son Co., The F. D.

Asphalt Plants.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
Littleford Brothers.
Warren Bros. Co.

Asphalt Railroad Plants
Cummer & Son Co., The F. D.
Warren Bros. Co.

Asphalt Tools.
Chausse Oil Burner Co.
Littleford Brothers.
Warren Bros. Co.

Asphalt Tool Wagons.
Chausse Oil Burner Co.
Littleford Brothers.

Auto Fire Apparatus.
Kissel Motor Car Co.
International Motor Co.
Pierce-Arrow Motor Car Co.

Automobiles.
Ford Motor Co.

Back Fillers.
Austin Machinery Corporation.
Pawling & Harnischfeger.

Bar Cutters and Benders.
Koehring Co.

Bars, Reinforcing.
Truscon Steel Co.

Binders, Road.
The Barrett Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Bros. Co.

Bitulithic Pavements.
Warren Bros. Co.

Blasting Accessories.
E. I. du Pont de Nemours & Co., Inc.

Blasting Powder.
E. I. du Pont de Nemours & Co., Inc.

Bodies.
Lee Trailer and Body Co.
Littleford Brothers.

Braces, Extension.
Kalamazoo Fdy. & Machine Co.

Brick Rattlers.
Olsen & Co., Tinius.

Brick-Testing Machinery.
Tinius Olsen Testing Mach. Co.

Brick, Paving.
National Paving Brick Mfrs. Assn.

Bridges.
Luten, Daniel B.

Buckets, Dredging, Excavating and Sewer.
Pawling & Harnischfeger.

Buckets, Dumping
Littleford Brothers.
Pawling & Harnischfeger

Cableway Accessories.
Sauerman Bros.

Cableway Excavators.
Sauerman Bros.

Calculators.
Kolesch & Co.

Car Unloaders.
Austin Machinery Corporation.
Heltzel Steel Form & Iron Co.

Castings.
U. S. Cast Iron Pipe & Fdy. Co.

Cast Iron Pipe.
U. S. Cast Iron Pipe & Fdy. Co.

Catchbasins.
Dee Co., Wm. E.
Madison Foundry Co.

Cement Gun Work.
Indiana Gunite & Const. Co.

Cement Testing.
Chicago Paving Laboratory.
Flood & Co., Walter H.
Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory.
Van Trump, Isaac.

Cement Testing Machinery.
Tinius Olsen Testing Mach. Co.

Central Heating Plants.
American District Steam Co.

Chemists, Engineering
Chicago Paving Laboratory.
Dow & Smith.
Flood & Co., Walter H.
Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory.
Van Trump, Isaac.

Chimneys, Concrete.
Truscon Steel Co.

Chimneys, Steel.
Littleford Brothers.

Chloride of Lime.
Pennsylvania Salt Mfg. Co.

Clay Pipe, Vitrified.
Clay Products Assn.

Clay Products.
Clay Products Assn.

Concrete Bridges.
Luten, Daniel B.

Concrete Mixers.
Austin Machinery Corporation.
Koehring Co.
Smith Co., T. L., The

Concrete, Reinforcement.
American Steel & Wire Co.
Truscon Steel Co.

Conduits.
Cannelton Sewer Pipe Co.
Carey Co., Philip, The.
Rosing, Inc., Astrid S.
Truscon Steel Co.

Conduit Rods.
Stewart, W. H.

Consulting Engineers.
Alvord, Burdick & Howson.
Artingstall, Wm.
Brossman, Chas.
Burd & Giffels.
Chicago Paving Laboratory.
City Wastes Disposal Co.
Dow & Smith.
Druar & Milinowski.
Flood, Walter H., & Co.
Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory.
Jones, Sam L.
Kirchoffer, W. G.
Kirschbraun, Lester.
Luten, Daniel B.
Potter, Alexander.
Van Trump, Isaac.
Wells, James P.

Contractors.
City Wastes Disposal Co.
Sullivan, Long & Hagerty.
Warren Bros. Co.

Contractors' Tools and Machinery.
Austin Machinery Corporation.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.
Smith Co., T. L., The

Contractors' Wagons.
Austin Machinery Corporation.
Austin-Western Road Machinery Co.

Conveying Machinery.
Mead-Morrison Mfg. Co.
Pawling & Harnischfeger.
Portable Machinery Co., Inc.
Webster Mfg. Co.

Cranes and Hoists.
Austin Machinery Corporation.
Heltzel Steel Form & Iron Co.
Pawling & Harnischfeger.

Creosote.
The Barrett Co.
Republic Creosoting Co.

Creosoted Wood Block.
(Factory Floors, Bridge Floors)
Republic Creosoting Co.

Crushers, Rock and Ore.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Culvert Pipe, Vitrified.
Cannelton Pipe Co.
Dee Clay Mfg. Co., Wm. E.

Culverts.
Austin-Western Road Machinery Co.
Newport Culvert Co.
Truscon Steel Co.

Curb and Gutter Forms.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Curb Bar.
Truscon Steel Co.

rd. from Afton to County line. Est. cost abt. $15,000. Ottawa Co. will pay half. J. M. Page, State Hwy. Engr.

Okla., Nowata—State Hwy. Dept. Okla. City, has plans for 86 miles hard surf. roads. Est. cost $500,000. J. M. Page, State Hwy. Engr.

Okla., Purcell—McClain Co. Commrs. plan to build 7 miles of highway betw. Purcell and Paoli near McClain and Garvin Counties line; state and fed. aid. Wil lalso erect brdg. over Walnut Crk. at edge of Purcell. $16,000. Plans to build sec. of State Hwy. betw. Newcastle Bridge on Canadian River and Grady Co. line on Tuttle Rd.; also rd. from Blanchard to Newcastle brdg. Abt. $80,000 available.

S. C., Columbia—State Highway Comn., Columbia plans elevating 2 sections of roads: Waterloo-Kemassee, approximately $41,000; Ridgeland-Hardeeville Rd. Approx. cost $22,000.

S. C., Spartanburg—City Commission plans to hard surface No. Harper and improve other streets. Considering $100,000 bond issue.

S. Dak., Desmet....Kingsbury and Brookings Counties making plans to regravel Black and Yellow Trail—Volga to Arlington. Brookings Co. Aud. Jno. Alton, Brookings; Kingsbury Co. Aud., H. O. Anderson, DeSmet.

Tenn., Cookeville—Putnam County Commrs. plan to complete road from corp. limits of Cookeville to Overton County line, via Algood; considering $61,000 bond issue; also plan to build road from corporation limits to Courthouse. Considering bond issue.

Tex., Anson—Jones County plans to expend $200,000 to improve State Hwy. 83; bond issue available. J. F. Lindsay, County Judge.

Tex., Carthage—Panola County plans 6.77 miles State Hwy. No. 8—Carthage to Murraul Creek. Est. cost $80,000; also bridges over 20-ft. span. Est. cost $49,000. Titus & Dillon, Co. Engrs.

Tex., Cuero—DeWitt Co. Commrs. Court contemplates bldg. 2 roads: 15.97 mi. gravel with bitum. top—Cuero to Gonzales. Est. cost $336,112; 5 mi. gravel Cuero-Forktown Rd. in Cuero-Westhoff bonded dist. Est. cost $42,812. Terrell Bartlett, Calcasieu Bldg., San Antonio, Engr.

Tex., Galveston—City plans to expend $100,000 to resurf. downtown streets; also $200,000 to improve streets in residential section. Bonds sold. Anne C. Kelly, Secy. Bd. of Commrs. Ed. M. Owens, Commr. of Streets.

Tex., Hillsboro—Hill County will soon receive bids for bitum. treat. surf. on 3.91 miles State Hwy. No. 6. W. J. Van London, Engr. in charge; W. L. Wray, Co. Judge.

Tex., Paint Rock—Concho County will soon receive bids to grade and construct bridges on section of State Hwy. No. 9. T. J. Kelly, Co. Engr.; R. Davenport, County Judge.

Tex., Rock Springs—Edwards County plans to grade and construct bridges on 16 miles State Hwy. 41, west from Rock Springs. $60,000. A. P. Allison, County Judge. W. E. Simpson Co. Engrs. National Bank of Commerce, San Antonio.

Tex., Seymour—Baylor County will receive bids soon to grade and construct bridges on 14.5 miles State Hwy. No. 30—Seymour to Knox County line. Approx .cost $42,000; also plans 50 mile State Hwy. 30—Seymour to Haskell. Est. cost $975,000. J. G. Rollins, Res. Engr. Box 696. Ernest Tibbitts, County Judge.

Tex., Sonora—Sutton County will soon receive bids to gravel surf. 6.06 mi. and crush stone surf. 5.19 miles State Hwy. 27—Southeast from Sonora. Est. cost $130,000. E. P. Stockton, Co. Engr., A. Johnson, County Judge.

Tex., Waxahachie—Ellis County plans 3.04 miles 18 ft. gravel on State Hwy. No. 14. Est. cost $52,000. W. A. Spalding, Co. Engr. H. R. Stovall, Co. Judge.

Va., Ft. Myer Hts.—Arlington County, Arlington Dis. plans road bldg. Contemplates $650,000 bond issue. Arthur Orr, Chmn.

Wn., Wenatchee—Chelan County rd. program for 1924 will include 15 pieces of rd. work. Jno. Duff, Co. Engr. Grading and surfacing of Chelan and Okanogan hwy., together with work on perm. hwy. 16, will be greatest piece of work. Total of $29,500 will be expended on this project.

W. Va., Huntington—City Commrs. plan leveling and repairing with asphalt, sections of Piedmont Road. A. B. Maupin, City Engineer.

W. Va., Huntington—City has decided to pave Third Ave. with brick. A. B. Maupin, City Engr.

W. Va., Marlinton—U. S. Forest Service, Pocahontas Co. and State Rd. Commission, Charleston interested in continuous State rd. No. and so. across Eastern West Virginia.

W. Va., Pineville—Wyoming County plans bldg 11 miles of road from Welch to Pineville. Est. cost $200,000. Will vote in November on bonds.

SEWERAGE AND SEWAGE TREATMENT

Cal., Beverly Hills—Salisbury, Bradshaw & Taylor, Mortgage Guarantee Bldg., Los Angeles, Cons. Engrs., have been commissioned to prepare plans and specfs. for sewerage disposal plant to serve population of approx. 12,000.

Cal., East San Diego—City trustees have started survey for sewers in 24 blocks of Lexington Park Dist., south of University Ave. section. Geo. A. Schwabland. San. Engr., San Diego, is investigating conditions for sewer system in Normal Heights, San Diego.

Cal., Firebaugh—Plans completed for 8,371 lin. ft. 6 and 10 in vit. clay sewer, 318 wye branches for house connections, sewerage disposal plant, Imhoff tank and dosing chamber, centrif. pumps with electric motors, etc. F. A. Gamboni, 515 Brix Bldg. Fresno., Engr.

Cal., Sonoma—Election planned here to vote on approx. $300,000 bonds for constr. of 3 miles sewer outlet to tide water.

Cal., Venice—Election planned to vote on approx. $300,000 bonds; construct sewer outfall.

Ont., Hamilton—By-law is to be submitted to ratepayers for constr. of intercepting sewer. Cost of work will be $423,000 and consists of sewer on Burlington St.; pumping station near West end of Strachan St. and a regulating chamber at Burlington and Ottawa Streets.

Ont., Leamington—Hersea Twp. plans 20 miles porous tile drains. Est. cost $100,000. A Hairsine, Clk:

Ont., Milton—Sanitary sewers are to be laid at cost of $34,000; storm sewers at cost of $20,000. G. A. Hemstreet, Town Clk.

Ill., Winchester—Bids will be advertised for in November for constr. of disposal plant 6.12 inch san. sewers, inlets, etc., in various streets. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo., Cons. Engrs.

Ia., Cedar Rapids—City considering constr. of sewage disposal plant. Thos. F. McCauley, City Engr. L. J. Storey, City Clk. $500,000.

Ia., Tama—The Izaak Walton League has served notice on Tama to install sewage disposal plant to stop pollution of Iowa river with sewage. D. A. Hurdough, City Clk.

Ia., Nashua—Prelim. plans being made for constr of sewage disposal plant. R. B. Slippy, 405 Lafayette Bldg., Waterloo. W. C. Kitchen, City Clk.

Ia., Waterloo—Resolutions proposed for sewers in Adams St.—4th to Ankeny; alley in Blk. 4,—Peok St. to Hewitt; W. 3rd—Fletcher to Vernon; Home Park Blvd.—Vernon to Drexel and Drexel—Home Park to Kingsley. City Clk., Chas. C. McKay.

La., Waverly—Prelim. plans being made for constr. of sewage disposal plant including septic tank, sludge bed, etc. R. B. Slippy, Engr., 405 Lafayette Bldg., Waterloo, City Clk. F. Lee.

Md., Baltimore—Bernard L. Crozier, Hwys. Engr. allotted $47,000 for bldg. at Back River sewage works.

Mich., Grosse Pointe Farms—(Branch of Detroit). Plans made for 3,000 ft. 10-in., 3,720 ft. 12-in. and 1,480 ft. 15-in. vit. crock sewers in Grosse Pointe Blvd. Est. cost $25,000. F. P. Walter, Village Engr.

Minn., Chisholm—$150,000 bonds voted here for sewer impvts., including sewage disposal plant. G. Anderson, City Engineer.

Minn., Rochester—Prompt action to be taken for constr. of Imhoff tank type of sewage disposal plant. City Engr. Armstrong. A. F. Wright, City Clk.

Miss., Pt. Gibson—City is having prelim. survey made of City for installation of sewage system; also purchase of light and water plant by private interests. M. L. Calley, Engr. Jackson, Miss.

Mo., Joplin—City Comissioner established Shoal Creek Sewer District No. 9 and will construct

BUYERS' GUIDE

Deep Well Pumps.
Harris Air Pump Co.
Keystone Driller Co.

Drag-Line Excavators.
Austin Machinery Corporation.

Drag Scrapers.
Austin-Western Road Machinery Co.

Drain Tile.
Dee Clay Mfg. Co., W. E.
Rosing, Inc., Astrid S.

Dryers.
Cummer & Son, The F. D.

Dump Cars.
Austin-Western Road Machinery Co.

Dump Wagons.
Austin-Western Road Machinery Co.

Dust Laying Compound.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.

Dynamite.
E. I. du Pont de Nemours & Co., Inc.

Edge Protector.
Truscon Steel Co.

Electrical Machinery.
Westinghouse Electric & Mfg. Co.

Electrical Wires & Cables.
American Steel & Wire Co.

Elevating Graders.
Austin-Western Road Machinery Co.

Excavating Machinery.
Austin Machinery Corp.
Pawling & Harnischfeger.
Sauerman Bros.
Smith Co., T. L., The

Expansion Joint Compound.
The Barrett Co.
Carey Co., Philip, The
Pioneer Asphalt Co.
Truscon Steel Co.

Explosives.
E. I. du Pont de Nemours & Co., Inc.

Fillers (Paving Joint).
The Barrett Co.
Carey Co., Philip, The
Pioneer Asphalt Co.
The Texas Co.

Fire Brick.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Flue Liners.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Forms, Sidewalks, Curb & Gutter.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms, Road.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Gas Pipe.
U. S. Cast Iron Pipe & Fdy. Co.

Gates, Sluice.
Coldwell-Wilcox Co.

Graders.
Austin-Western Road Machinery Co.

Granite Block.
Granite Paving Block Mfrs. Assn. of the U. S., Inc.

Gunite.
Indiana Gunite & Const. Co.

Heaters (Rock and Sand).
Littleford Bros.

Heating Plants, Central.
American District Steam Co.

Heating Wagons (Oil and Tar).
Good Roads Machinery Co., Inc.
Littleford Bros.

Hoists (Concrete, Gasoline and Hand).
Pawling & Harnischfeger.

Hoists, Electric.
Mead-Morrison Mfg. Co.
Pawling & Harnischfeger.

Hoists, Steam.
C. H. & E. Mfg. Co.
Mead-Morrison Mfg. Co.

Hot Mixers.
Austin Machinery Corp.

Inlets (Sewer).
Dee Co., Wm. E.
Madison Foundry Co.

Insulating Material.
The Barrett Co.
Pioneer Asphalt Co.

Joint Fillers (Paving).
The Barrett Co.
Carey Co., Philip, The.
The Texas Company.

Kettles (Portable).
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Littleford Brothers.

Manhole Covers.
Madison Foundry Co.
Dee Co., Wm. E.

Mastic.
The Barrett Co.
Pioneer Asphalt Co.

Meter Boxes.
McNutt Meter Box Co.

Mixers, Asphalt.
Austin Machinery Corporation.
Cummer & Sons Co., The F. D.

Mixers, Concrete.
Austin Machinery Corp.
Koehring Co.
T. L. Smith Co.

Motor Fire Apparatus.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
Pierce-Arrow Motor Car Co.

Motor Trucks.
Duplex Truck Co.
Federal Motor Truck Co.
Ford Motor Co.
International Motor Co.
Kissel Motor Car Co.
Pierce-Arrow Motor Car Co.

Motor Truck Flushers, Sprinklers, and Oilers.
Acme Motor Truck Co.
Austin Machinery Corporation.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
The Gramm-Bernstein Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
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E. I. du Pont de Nemours & Co., Inc.

sewer in alley east of Main from 32nd to Shoal Creek public sewer.

N. J., Manasquan—Plans being made for sewerage system in various streets. $35,000. L. C. Riddle, Mayor.

Ohio, Cedar Point—(Sta. Sandusky)—G. B. Gascoigne, Leader-News Blg., Cleveland, Ohio, Cons. Engr. for sewage treatment plant to cost $50,000.

Okla., Wetumka—City will vote on $20,000 sewer bonds, $63,000 electric bonds, $52,000 water bonds. V. V. Long & Co., Engrs., Concord Bldg., Okla., City.

Tex., Bastrop—City (P. C. Maynard, Mayor) considering installation sewer system. Griffith Engrg. Co. Cons. Engrs., Dallas, Tex.

Tex., Caldwell—City having plans prepared by Municipal Engineering Co., Dallas, for completing sewer system. $45,000.

Tex., Groveton—City will vote on $35,000 for sewer system here.

Tex., Livingston—City will vote on $40,000 bonds for sewer system.

Tex., Wichita Falls—City contemplates voting on $150,000 bonds for installing sewage disposal plant.

Va., Roanoke—City Mgr. Hunter considering installation of sewers in Norwich, Northwest and Southeast. Est. cost $30,000.

Wis., Elkhorn—Plans being made for sewage disposal plant, including two 40x90 sand filters, siphon chamber and concrete walk around filter bed. W. G. Kirchoffer, Engr., Dean Bldg., Madison. City Clk. W. Kinne.

WATER SUPPLY AND PURIFICATION

Ala., Huntsville—Whitesburg Pike Water Line Co., incorporated with A. T. Terry, Pres.; A. M. Hutcheson, Secy., will extend water main of City a distance of 5 miles on Whitesburg Pike.

Alaska, Juneau—Juneau, Alaska, Water Company plans extensive water main installations as soon as street improvements are made. Latter impvt., however, may hold up installation until next year.

Cal., Los Angeles—Los Angeles Midway Pipe Line Company (Doheny interests) has applied for franchise to construct three 8-in. pipe lines through City, involving expenditure of several million dollars.

Cal., Pasadena—City has purchased 3½ acres on Calaveras St., adjoining the Mountain View Cemetery, Altadena, as site for 10,000,000 gal. reservoir. Samuel B. Morris, Chf. Engr. Water Dept.

Cal., San Bernardino—Chamber of Commerce is investigating proposal to utilize waters of Lake Arrowhead for domestic water supply. R. H. Mack, Secy.

Cal., San Francisco—The $10,000,000 Hetch-Hetchy water proj. carried at recent election. plan is to construct 17-mile tunnel aqueduct, Mocassin Crk. aqueduct to Oakdale portal thru Sierra foothills to west extremity of present, and a 31-mile tunnel thru coast range. Constr. program covers 3-year period.

Cal., Santa Ana—City Council taking steps to provide City with permanent gravity water system adequate for 100,000 population. Plans involve possible cooperation with Orange, in which case 2 reservoirs would be needed. Conservative est. of capy. of reservoir to supply Santa Ana (10,000 population), is $50,000,000 gals.

Cal., Santa Barbara—Hearing on proposed $140,000 hydro-electric plant bond issue will be held Oct. 16th.

Ont., Lasalle—Essex Border Utilities Commission water system will be extended to supply La Salle. Total cost of extension $385,530.

Ont., Ford—Bids will soon be asked for pumping station, J. Clark Keith, Cons. Engr. Cons. Engrs. Gore, Nasmith & Storrie, Toronto.

Ont., Hamilton—City Engr. W. L. McFaul, Hamilton, instructed to submit report to Water Committee on the feasibility of a City water supply from nearby mountains.

Ont., Sault Ste. Marie—Gasoline unit is to be installed to act as auxiliary pump; water mains will be laid on Dyment, Letcher and McNab Sts. R. G. Campbell, Clerk.

Ont., Windsor—Pipe line is to be laid from Windsor to Sandwich, Ont.

Fla., Coconut Grove—City has had plans prepared by Main Engrg. Co., Daytona, Florida, for water works and distribution system. $200,000 available. Geo. A. Main, Cons. Engr.

Fla., Pensacola—U. S. Navy Dept. will expend $150,000 for installation of water works at Naval Air Station, including storage reservoirs with 20,000,000 gal. capy. and drilling artesian wells.

Ill., Springfield—Comr. W. J. Spaulding and H. F. Ferguson, Chf. State Engr. of Illinois, conferred with C. S. Timanus of Burns & McDonnell Engrg. Co., Kansas City, Mo., over plans for new iron removal and filtration plant for City water works.

Ia., Woodward—Action soon on plan presented by Engr. Lafayette Higgins, 420 Security Bldg., Des Moines, for extension of water system to connect with State hospital. H. R. Chamberlain, Twn. Clk.

La., Gretna—City has plans by Major T. Payne, Cons. Engr., Jefferson Bank Bldg., Algiera, La., for constr. of water works system. Election Dec. 12th, to vote on $165,000 bonds.

La., Shreveport—City will extend water works and sewerage sys.

Md., Baltimore—V. Bernard Siems, Water Engineer, allotted $23,000 for water main extension.

Minn., Virginia—Plans approved and work will soon start on construction of reservoir at Missabe Mtn., Reservoir, pumping plant and pipe line connecting with City water system. A. E. Bickford, City Clk.

Minn., Winona—Plans made for rein. conc. reservoir and pump house. Cons. Engrs. Alvord, Burdick & Howson, 8 S. Dearborn St., Chicago, Ill. Est. Cost of impvt. $225,000. Geo. W. Hoffman, City Clk.

Miss., Pass Christian—City Council plans to extend water works system.

Mo., Aurora—Lawrence County Water, Light & Cold Storage Co., Aurora, plans to increase capital from $250,000 to $450,000. Impvt. of present property, purchase of Billings Light, Power & Water Co. extension of a line to Republic, Mo., are among projects under construction.

Mo., Kansas City—Fuller & Maitland, Cons. Engrs., 600 Walnut St., Kansas City, are preparing plans and specfs. covering items of constr. in connection with bldg. water plant. Will submit same to Fire and Water Board about Feb., 1925.

Neb., Dunbar—Voted in favor of $17,500 bond issue at recent election here. Henningson Engrg. Co., 301 National Bldg., Omaha., Engrs. H. S. Westbrook, City Clk.

Neb., Falls iCty—City contemplates constr. of water filtration plant with water being secured from Nemaha River. Report made by Henningson Engrg Co., 3rd Flr. National Bldg., Omaha.

N. Y., White Plains—Following fire here (Gedney Farms) a movement has been started for issuance of $500,000 bonds for distribution system impvt. for better water supply and fire protection.

N. Car., Davidson—City (W. H. Thompson, Clk.) considering issuance of $80,000 water bonds.

Ohio, Dayton—Mr. Leonard Metcalf (Metcalf & Eddy, Cons. Engineers, Boston, Mass.) is conferring with City officials at Dayton with regard to proposed new pumping station for City water works.

Ohio, Georgetown—Chamber of Commerce considering constr. of municipal water works system here. Dr. R. E. Schwartz instructed to have preliminary estimates made.

St. Marys, O.—Ohio State Department of Health has advised abandonment of existing water wells and the constr. of new well system. City Council considering the project.

Braman, Okla.—Bids will probably be asked in November for water works project including small pump house; installation of 2 200-g.p.m. direct connected motor driven pumps and 50,000 gal. elevated tank. H. E. Musson & Co., Engrs., 401 Grain Exchange Bldg., Okla. City. Will expend abt. $25,000. A. O. Via, Clk..

Easley, S. C.—$150,000 water and sewer bonds voted.

and Market Sts., will construct 12-in. water main on 3rd and High Streets. A. F. Porzelius, Mgr.

Brownfield, Tex.—City has preliminary p'ans by Montgomery and Ward, Cons. Engrs., City National Bank Bldg., Wichita Falls, Texas, for water works system. May vote on bonds.

W. Va., Riversville—$50,000 bonds voted here for water works.

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Austin-Western Road Machinery Co., The

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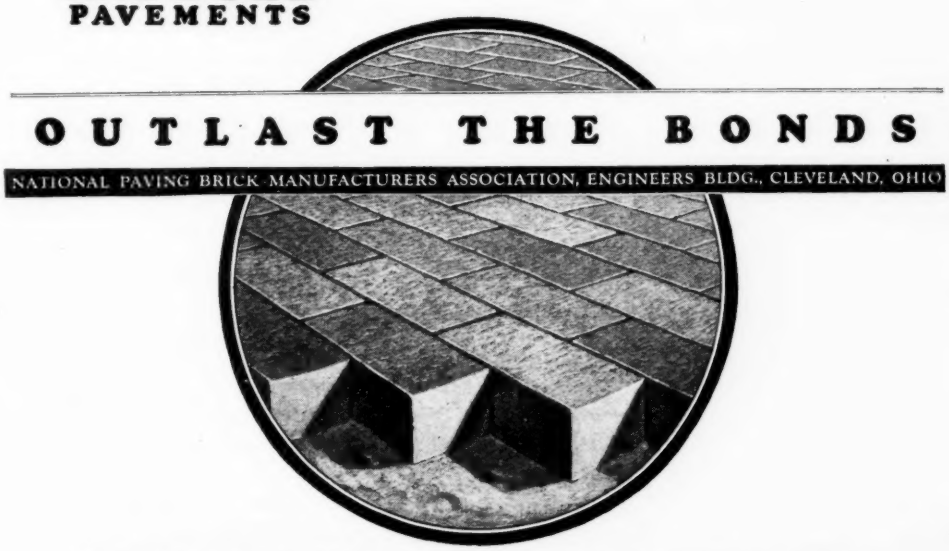

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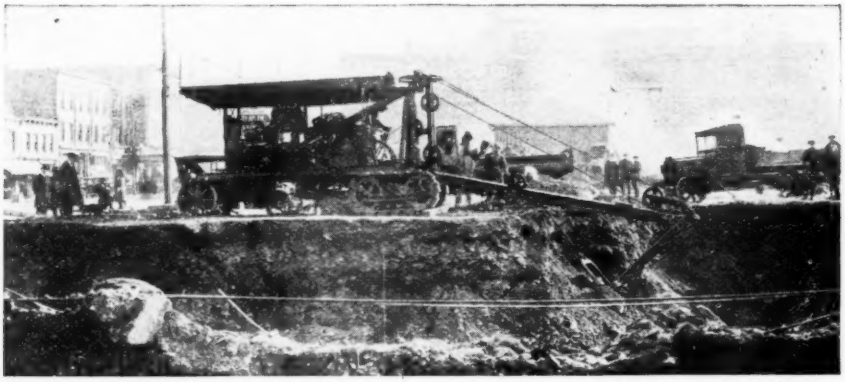

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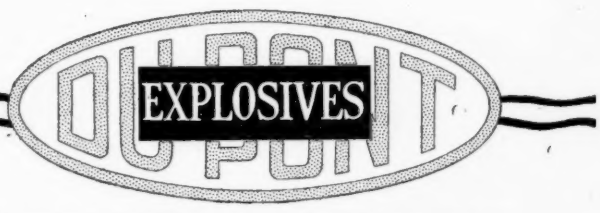

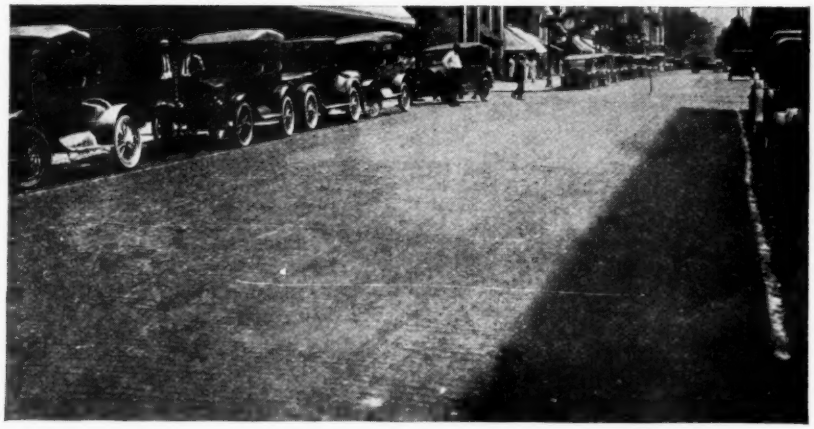

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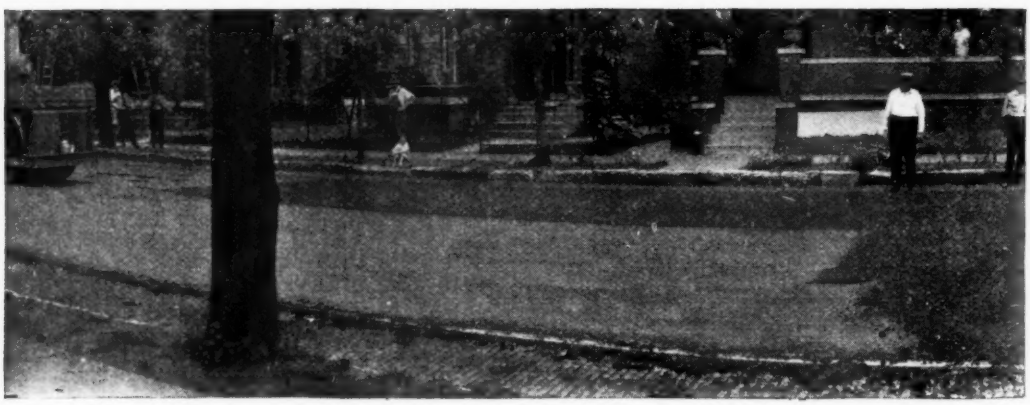

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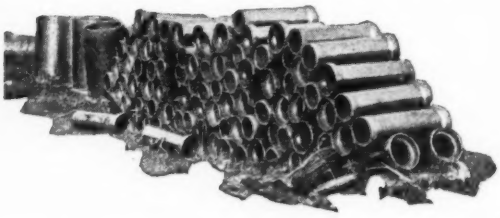

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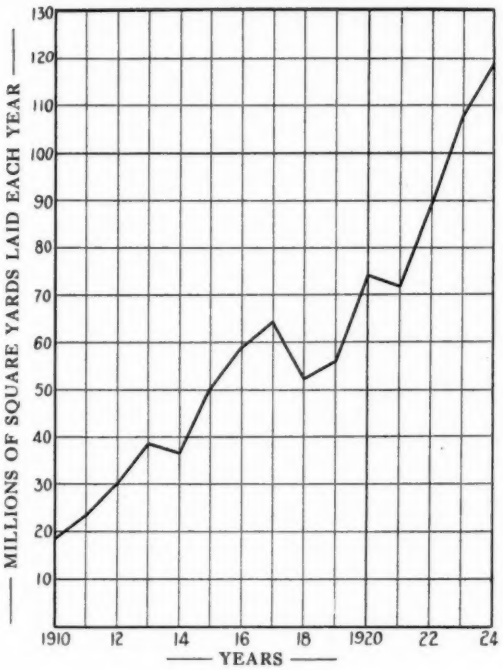

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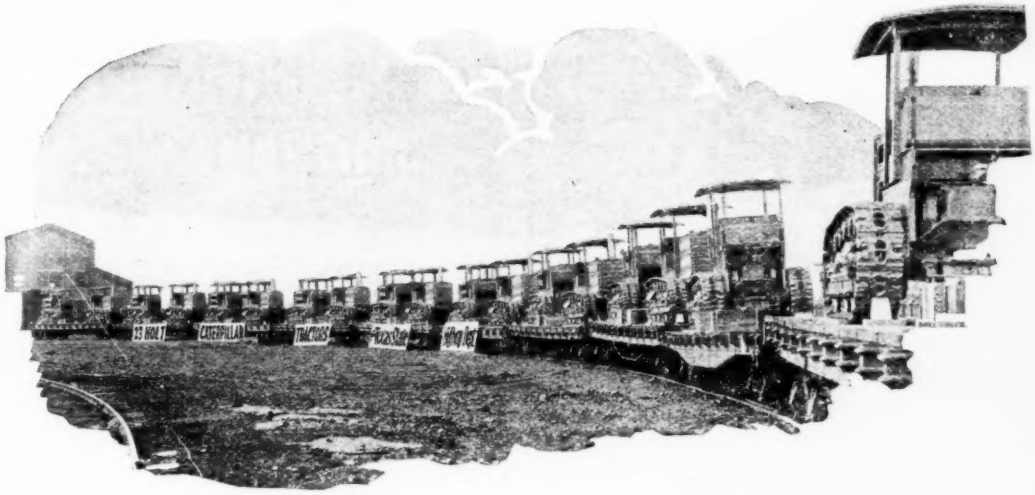

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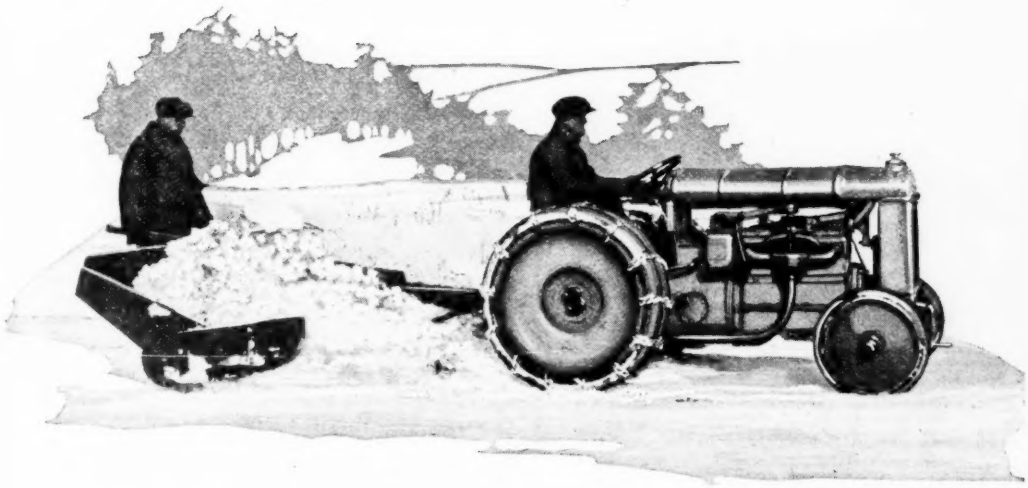

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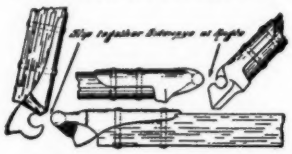

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BUILDING A STATE HIGHWAY SYSTEM BY BOND ISSUE

By Maj. C. P. Fortney, Chairman West Virginia State Highway Commission

Within the last twenty years, road building has become one of the leading activities of our nation. As we are all aware, this renewal of highway construction is due to the motor vehicle, which must have hard roads in order to take its rightful place as one of the most important factors in modern transportation.

Early in the last century the stage coach became a transportation agency whose importance, to the people of that period, was fully as great as that of the automobile is to us today. The era of the stage coach was also an era of road improvement, which, it appeared, would go on indefinitely. But the railroad came, and with its coming the stage coach vanished, the need for good highways was overshadowed by the need for railways and for more than half a century road building is many parts of the United States became ancient history.

There was always a mild agitation for better roads, based chiefly upon the needs of the farmer. It was argued that if the farmer could haul his crops to town or to the railroad station whenever he wished, and could haul a bigger load, he would profit considerably. In the more progressive communities this brought about some road improvements. What was called a good road in those days was one over which horse-drawn wagons could pass without sinking in. Such a road was usually built by breaking stone and spreading it over the surface, and the cost was met by a small tax levy. When the bicycle was invented and came into general use, a demand for smoother road surfaces arose and led to some further improvement, especially in and adjacent to towns and cities.

A little later came the automobile, and with it a good roads revolution. We are now in the midst of that revolution, and if we are to fight its battles successfully we must have armies of dollars.

The question of how these dollars are to be raised is one that is being discussed at length in every state in the Union, and this brings us to our subject, "Building a State Highway System by Bond Issue."

The Pay-as-You-Go Plan

The only alternative to bond issues as a method of raising the large sums required for modern hard roads is the "pay-as-you-go" plan, that is, to spend each year only what money can be raised that year through taxation. The great and obvious objection to this plan is that the burden of taxation sufficient to pay for a large mileage of roads in any one year, or even in several years, would be unbearable. So, if a state or community uses the "pay-as-you-go" plan, it must build only a comparatively small mileage each year.

This policy is unwise because it costs any community more to do without good roads than it does to build them. To remain surrounded by poor roads means to remain cut off from the rest of the world. In former times trade followed the flag. Now it follows the good roads. Motor car traffic has become vital to business and industry, and the state, city or community which is easily accessible to this traffic has an incomparable advantage over those which are not so fortunately situated.

Every community which does not have good roads wants them quickly, and can not get them except by the expenditure of far larger sums than can be raised in one year or in a few years. This means that money must be borrowed, and the security for the borrowed money is in the form of bonds.

Life of Bonds

Having decided to issue bonds, one of the important questions that the political unity issuing them must consider, is the number of years to elapse before they are paid off. As a general principle, it is believed that the life of road bonds should not exceed the life of the road. Otherwise, there will be a pyramiding of bond payments for the same section of highway. That is, after the road built with the first bond issue has worn out, more bonds are issued and the road is rebuilt. The taxpayers are then paying on two bond issues for the same road, and if the bonds are of the long-term variety, they may be paying on three or even four issues before the first ones expire.

However, in considering this point, it must be kept in mind that the life of the paved surface is not the life of the road. After the surface is worn out, the grading, drainage, and foundation usually remain good, so that in most cases resurfacing will restore the highway to its original condition. The life of the surface may be 15 or 20 years, and the life of the more permanent parts of the road 50 years or more. Since the

permanent parts of the road usually cost less than a high type of hard surfacing, the life of the bonds should probably be somewhat less than the average of the lives of the hard surface and the more permanent parts.

In case bonds are issued to pay for the resurfacing of such a road, there is no duplication of bond payments, because that part of the original bonds covering the original surface may be regarded as paid. These figures, of course, can be only approximate, as the surface may last longer, or wear out sooner, than estimated at the time of construction. As a rule, however, the principle will work out in a satisfactory manner.

Bonds issued for a term corresponding to the life of the road are called short-term bonds, regardless of the number of years they run. The issuing of bonds for a term extending far beyond the life of the road affords an easy way to finance road building, but is unfair to the next generation, which will be paying for something that no longer exists, and from which the preceding generation received all the benefit.

While the term of road bonds should coincide as closely as possible with the life of the improvements, it is a fallacy to suppose that the "pay-as-you-go" plan costs the people less than a bond issue. It is quite true that if we pay cash for roads we do not have to pay interest on borrowed money, but this is more than balanced by the earning power of a hard road.

As soon as a road is built, it begins to earn money for every motor vehicle owner who uses it, and for every farmer through whose property it passes.

When Roads Pay for Themselves

It has been found by comprehensive tests, that in money saved to motor vehicle owners, a modern paved road will pay for itself in an average period of five years. What a hard road earns for the farmer, the dairyman, the market gardener, the stock raiser, and the fruit grower, can not be so accurately measured. We know, however, that the value of all real estate is increased by a paved road, and that the producer who lives along such a road can haul his products to market covering a much wider radius, can haul bigger loads, and can wait until that season of the year when prices are highest, regardless of weather conditions. Then there is the money value to a community of having a road over which tourists may pass. These people from the outside on vacation trips have money to spend and are usually in a spending mood. They must buy their necessities at least, as they pass along, and the bare necessities of automobile travel amount to a considerable sum.

All of these things, added to the savings effected for the motor vehicle owners of the state in which the roads are located, operate to reduce the period in which a hard road will pay for itself to considerably less than five years—probably to not more than three.

Highway Bond Debt Not Large

The use of bond issues has been quite general. The most recent statistics of the U. S. Bureau of Public Roads show that all except two of the states have issued road bonds, either state or local, North Dakota and Vermont being the exceptions. However, these bonds have not added a very startling amount to the national indebtedness. Of the total indebtedness of the United States and its political subdivisions, highway bonds constitute 3.9 per cent.

In West Virginia, we are building a state road system by a state bond issue. To make this method possible, it was first necessary to amend the constitution and this was accomplished in 1920, the amendment having been adopted by a large popular vote.

Road Conditions in West Virginia

Prior to that time, the progress of road improvements in West Virginia had been distressingly slow. In 1914 it was declared by the head of our State Road Bureau, in his annual report, that West Virginia had the worst roads in the United States. In 1917 the legislature passed the state aid law, under which the state agreed to match sums raised by the various counties to construct roads according to certain standards. Some of the counties took advantage of this state aid, but many did not. About the same time, Federal aid was put into operation, and the funds received from this source were used to good advantage. But even with both state and Federal aid, the mileage constructed was comparatively small, and the pressing need for improved roads in every part of the state was painfully apparent.

Some of the wealthier and more progressive counties had issued bonds, but for the most part had reached the limits of their willingness or their resources. A general survey of the situation indi-

cated that road building in West Virginia was about to come to an abrupt and inglorious end.

In this crisis, those who realized the value of good roads began to cast about for some method by which West Virginia might be lifted out of the mud. Careful consideration convinced them that a bond issue would meet the situation far better than to build each year only what could be paid for by current taxation.

An association of good roads boosters was formed, and a systematic campaign of education was started. It was pointed out that the situation in West Virginia was especially favorable to a bond issue. The population, and the valuation of taxable property, were increasing rapidly, and the development of the great natural resources of the state was being blocked by mud. Oil and gas fields, coal and timber areas, were almost inaccessible. Since most of the counties had done all that they could, or would, it was evident that there could be no comprehensive program of road construction except by the state as a whole.

The Bond Campaign

This campaign was successful. The constitutional amendment, as passed by the people, provided that a state road system should be constructed, to connect at least the various county seats, and that to provide money for this work, the legislature should have power to authorize the issue and sale of bonds not to exceed $50,000,000 outstanding at any one time.

At the next session of the legislature, it was voted to issue $15,000,000 of the road bonds, and to place both the designation and the construction of state roads in the hands of a State Road Commission of three members, to be appointed by the Governor.

County Aid

It was provided that 80 per cent of the proceeds of the bonds should be divided among the 55 counties of the state according to their respective mileage of Class A roads. The name, "Class A" had no reference to the nature of improvements that had been made on the roads. In fact, most of them had not been improved in any manner. Class A roads in West Virginia were main county roads, and roads receiving Federal or state aid. Since Federal and state aid, as a rule, had been given only on main county roads, and since not more than two roads in each county could be accepted by the state as main county roads, the Class A roads were usually one main east-and-west and one main north-and-south road of each county, extending from border to border. In effect, the apportionment of funds according to Class A mileage, was virtually the same as according to area, since a large county would necessarily have a large Class A mileage, and a small county a much shorter mileage. This system of Class A roads had been adopted in connection with the state aid plan. It was abolished by the same law that created the state system, only the mileage being retained as a basis for the division of funds.

The remaining 20 per cent of the bond proceeds was to form a reserve fund, to be expended at the discretion of the State Road Commission, to make desirable connection or to economize in construction.

The Bonds

The first issue of $15,000,000 in road bonds was dated July 1, 1921, and becomes payable serially in equal installments, beginning July 1, 1927, and ending July 1, 1946. Interest is payable semi-annually at 5 per cent. To retire the principal, the legislature created a state road sinking fund. This fund consists of sufficient money each year to pay interest, and one twenty-fifth of the principal. After the treasurer has paid the interest, he is required to turn the remainder of the fund over to the state sinking fund commission, which is empowered to invest the money in bonds of the government of the United States, bonds of the State of West Virginia, or bonds of any political subdivision of the State of West Virginia. It is provided that bonds so purchased shall mature so as to provide sufficient money to pay off the road bonds as they become due. The road bonds can not be sold for less than par and accrued interest, and sales are in the hands of the Governor. The first issue was sold in the fall of 1921.

The legislature of 1923 authorized the sale of an additional $15,000,000 to be dated April 1, 1923, with serial payment to start April 1, 1929, and to end April 1, 1948. The rate of interest on this bond issue is 4½ per cent. It has also been sold.

There remain to be authorized, bonds of a par value of $20,000,000 to bring the total outstanding up to the constitutional limit of $50,000,000.

Counties Do Much Work

The state program, and Federal Aid, have proved an inspiration to many of the counties, which have expended considerable sums of their own money either on state routes or on county roads connecting with state routes. Up until the first of this year, 41 counties out of 55 had issued road bonds, the total of which was $34,333,200.

When the authorization of bonds was before the legislature, there was considerable debate over what roads should be improved. A number of members advocated the building of main trunk lines entirely across the state before anything else was done, but this plan was opposed and defeated by those who believed that work should be carried on simultaneously in every county. Main trunk lines are unquestionably of great value. They connect a state with the outside world, and serve a large number of people within the state. However, it is a fact that the bulk of the traffic in any state is over short distances, and is carried on other than trunk lines.

While our West Virginia law requires that 80 per cent of the bond funds be apportioned among the 55 counties and expended simultaneously, the fact that the State Road Commission is authorized to expend the remaining 20 per cent on desirable connections makes it possible to do considerable work on trunk lines. We have interpreted the term, "desirable connections," to mean desirable to the greatest number, and this, of course, applies to the main roads. It is also possible, in many cases, to use part of the regular county apportionments on trunk lines, since these main roads are usually county-seat connections.

We must keep in mind that to be popular, a bond issue must include roads in every part of the state.

Following the principles laid down in the state road law, the State Road Commission of West Virginia has designated state routes with a total mileage to date of 3,582. This provides for the linking up of all the county seats and for connections with the main roads of adjoining states.

Construction and reconstruction was started on state routes in the spring of 1922. Out of the total of 3,582 miles, we now have 2,030.71 miles either improved or under construction.

With the two state bond issues of $15,000,000 each, and Federal aid totaling $2,033,352.08, the State Road Commission has built or placed under construction, a total of $1,223.79 miles of roads, 91 large bridges and 250 small bridges, and has reconstructed a large mileage of roads taken over on state routes from the various counties.

It is generally believed that the coming legislature will authorize the sale of the remaining $20,000,000 in bonds, and if that be done it will enable the Commission to continue the present program without interruption.

Initial Delay

It is of first importance that the funds raised by a bond issue be promptly available for construction. In West Virginia, we were unable to sell our first $15,000,000 through the usual channels, owing to the unfavorable state of the bond market at that time, and also partly owing to the provision in the law that they could not be sold for less than par and accrued interest. Finally, a group of West Virginia bankers patriotically agreed to take the bonds in order to get the road program started. As a condition of this sale, it was agreed that the proceeds should remain on deposit in the banks and be paid in installments. The banks, of course, have paid the state interest on the balances, but the installment plan of payment gave the Road Commission only $3,900,000 in the calendar year 1922, so that our program did not get well under way until the season of 1923.

Even with this handicap, however, there is a marked contrast between West Virginia roads of 1920 and 1924. Almost all our cities and larger towns are now linked together by improved highways, and the construction program is being rushed forward at high speed. During the present season, we have completed 319 miles of roads, and will add largely to that mileage in the next six weeks.

Increase in Motor Vehicle Registration

The rate at which we have been building roads is reflected in the rate of increase of automobile registration, which for last year was 43.7 per cent.

This great increase in the number of motor vehicles is a matter of considerable interest to our taxpayers, in connection with the state road bonds. When we were conducting our campaign for a bond issue, we told the public that with the improvement of our roads, we might reasonably expect to have 123,000 motor vehicles by the year 1923. Our prophecy

was more than fulfilled, for the number of motor vehicles registered in West Virginia in 1923 was 197,989. In the bond campaign, we estimated that the receipts of the automobile department in 1923 would be $2,032,000. The actual figures were $2,951,935.41. We have now reached the number of registrations and the receipts which we predicted for the year 1927.

Motor Revenues to Refund Bonds

One of the arguments against the bonds was that they would bring with them an added burden of taxation. In fact it was anticipated even by the best friends of the bond issue that some added taxes would be necessary, but it was contended that the benefits would be overwhelmingly greater than the additional taxes.

To the surprise of everybody, the construction of our state road system by a bond issue has not, so far, required a single cent of taxes from the general property owner. The money required to pay interest on the bonds, provide the annual sinking fund for the principal, pay the costs of road maintenance, and meet all the overhead expenses of the State Road Commission, is all being provided by the receipts from automobile licenses, and the gasoline tax. The total receipts from the two sources last year were $3,754,926.57. This was not a full year for the gasoline tax, as it did not go into effect until July 27.

In other words, the motor vehicle owners of West Virginia are paying for the construction and maintenance of the state road system. Unless a man owns an automobile or a truck he is not paying a cent for state road purposes, and if he does own a machine, improved roads are saving him every year, several times the cost of his license and gasoline tax.

We believe that we may say, therefore, that the building of a state road system by bond issue in West Virginia has been a marked success.

The foregoing paper by Major Fortney was read at the Third Asphalt Paving Conference, held in Louisville, Ky., Oct. 13-15, 1924.

SUPER-HIGHWAYS OF THE 20TH CENTURY

By Edward N. Hines, Chairman Board of County Road Commissioners, Wayne County, Detroit, Mich.

Progress in concrete highway building can well be epitomized in the following outline of what Wayne County has done, and its probable future development seen in what we are now planning to do. Although I understand that today there are some 31,000 miles of concrete in service in the United States, Wayne County, which took its place 15 years ago as the pioneer in concrete road construction, is still a pioneer.

The Beginning

Back in 1906, the Board of County Road Commissioners in Wayne County was created for the purpose of improving the county's important highways. At that time there was not a single mile of improved road nor an adequately paved village street in the entire county. The automobile was looked upon largely as a toy or a luxury, and motor trucks were hardly known.

This newly created County Road Commission, of which I was a member, made a survey of the county and laid out a systematic, continuing plan of road improvement covering a period of years toward which to work as funds became available.

This survey contemplated the improvement of approximately 350 miles of the 1,370 miles of public road outside of the cities and villages. It has been rigidly adhered to and the entire 350 miles originally planned have been constructed, plus 40 miles additional to meet conditions that have arisen since.

Concrete Road, Standard Type

While no changes have been found desirable in the routes selected for improvement, there have been important changes in the character of roads built. Types of construction that were deemed standard in 1906 soon proved too expensive to maintain and were otherwise inadequate, so that following satisfactory experiments with concrete, in 1909 we adopted the concrete road as our standard type and have built practically nothing else during the past 15 years.

Widths Increased

During the past 9 years the ownership and use of motor cars of all kinds in Wayne County has increased nearly 14 times as fast as the population.

Every day more and more people are using the motor car. Noting this development several years ago and being confronted with increasing maintenance charges on the shoulders of our concrete roads, we increased our minimum width of metal to 20 ft., making 30 ft. over all. We also started in to widen to 20 ft. or more all concrete that, because of the demand for mileage, had previously been constructed of a lesser width than 18 ft.

We also increased the capacity of our bridges to a 30-ton live load and their clear roadway width to a minimum of 27 ft., building largely a T-beam and slab type with a precast concrete ornamental handrail. This type of bridge lends itself to future widening without any great loss of the initial investment.

Rights of Way

Realizing that rights of way are fundamental, our Commission for several years past has been groping around in an effort to correct and relieve traffic congestion. One hundred foot rights of way have been acquired on some of our radial roads out of Detroit, such as Woodward, Michigan and Grand River Roads. Many double concrete highways have been constructed, ranging from 40 ft. in a single roadway to 70 ft. between curbs with provision for interurban tracks in the center.

But no sooner has an improvement of this character taken place than the road immediately becomes congested with traffic. We have come to realize that half measures are useless and are now striking out boldly with a new plan in co-operation with the Rapid Transit Commission of Detroit and the Road Commissions of Oakland and Macomb Counties. All the history of the past shows that our failures have been due to underestimating the future rather than in overshooting the mark.

In conjunction with the Rapid Transit Commission all of the territory in Wayne, Oakland and Macomb Counties that lies within a 15-mile radius from the Detroit City Hall is now being mapped with respect to the widths of rights of way of all mile, half-mile, radial, and other important roads. Every half-mile road is being planned for a minimum 86-ft. width, every mile road a full 120 ft., except that every third mile road is having 84 ft. added for future rapid transit needs, making a total of 204 ft. for these super-highways. Radial main arteries, which are of greater importance than meridian roads, since they have no main parallel highways, are being planned for a right of way of 204 ft.

The Rapid Transit Commission arrive at the 204-ft. figure for their super-highway by taking a width of 120 ft. for an arterial city street, and adding 84 ft. to it for surface rapid transit. Where interference with the foundations of adjoining buildings is to be avoided and main sewers provided for, 120 ft. is the desirable width for a 4-track underground rapid transit line. A 120-ft. street with a 4-track rapid transit beneath it may be looked upon as a double-deck or two-level thoroughfare.

If, at the edge of the built-up area of the city, the 4 tracks are brought out from underground and laid upon the surface with grade separations every half mile, and if the former 120-ft. street is divided into two 60-ft. sections which are placed one on each side of the surface rapid transit facilities, then we will have a single level thoroughfare, with the same four rapid transit tracks and the same 120 ft. for vehicles, pedestrians, tree planting, etc.

Objects in Obtaining Wide Rights of Way

Col. Sidney D. Waldon, Chairman of the Rapid Transit Commission, gives the main objects in obtaining the wider rights of way, substantially as follows:

To permit a variety of treatment in pavements, tracks, tree planting, etc., depending upon the requirements of the territory traversed.

To give increased capacity, with increased speed and safety for motor vehicle transportation, regardless of any other use to which it may be put. This means individual and collective rapid transit on rubber tires, until such time as the density of population demands rail transportation.

By proper spacing of vehicle roadways, while retaining the center free, to provide for future train-operated rapid transit on the surface at half the cost for an underground system. By reason of the lower cost, rapid transit can be provided at a much earlier date, or for the same money, over a much larger area.

When surface rapid transit is provided with grade separations at the station points at half-mile intervals, the express-motor vehicle roadway can also be carried over the same intersecting streets,

and provide a new facility not now available to the motor vehicle owner anywhere in the world.

The wide right of way, regardless of the particular form of development that may be used, will have surface capacity sufficient to take care of the circulation and transportation of the occupants of the tallest structures. Being wide, the super-highway will not only invite major improvements of this character, but it will give them the maximum of light and air, and a splendid setting.

Regardless of whether the super-highway is developed wholly for vehicular traffic, or vehicular traffic and street cars, or for vehicular traffic and rapid transit, it will permit of the planting of trees and shrubbery in places along its route where they will not be disturbed by the successive steps in its development.

Much emphasis has been placed on the element of safety and relief of traffic congestion in planning for wider rights of way. We believe that one element has been overlooked, that is the time factor through greater allowable speeds, which will restore to the automobile that large element of usefulness that has been taken away from it through narrow roads and streets.

The thing that is vital and fundamental is to obtain the rights of way now as the land naturally will never be cheaper than it is today. The construction of the highways themselves will be a gradual process.

For the successful working out of the foregoing plan there are still some vital, necessary steps to be taken by the communities interested. Chief of these will be a special act of the State Legislature creating a transportation district with the administrative authority to plan for financing the acquisition of the necessary rights of way.

Wayne County, however, has not waited for such legislation but has proceeded under existing laws as rapidly and as steadily as those limitations permitted.

During the fiscal year just closed, over $800,000 was expended in acquiring additional rights of way, and in 1925 we expect to invest upwards of a million dollars for similar purposes.

We have also established as a policy an ultimate minimum width of 40 ft. of concrete on all of the main highways in Wayne County and all roads are now being graded to a width of 40 ft. so that when it becomes necessary to widen we will have a firm subgrade on which to work. Two crews, during the working season, are being kept busy continuously widening all concrete roads of a lesser width than 18 ft.

In highway planning, failure to look ahead not only handicaps the development of the community, but invariably proves most costly in the end. Our experience shows the necessity for the immediate widening of roads near large centers of population, and of now laying definite plans and securing rights of way for much greater widths in the future.

BLACK BASE CONSTRUCTION INCREASES IN MIDDLE WEST

By Hugh W. Skidmore, Chicago Paving Laboratory, Inc., Consulting Engineers, 536 Lake Shore Drive, Chicago, Ill.

Noteworthy increase of yardage of black base or asphaltic concrete base construction, has taken place in the middle states during the last two or three years. This fact alone is ample evidence of the economy and practicability of this type of construction. Prior to a few years ago, there was a fair yardage of black

VIEWS OF BLACK BASE CONSTRUCTION ON E. CHESTNUT ST., QUINCY, ILL.
Left: Heavy Grading. Right: Shows Three Successive Steps: Finished Subgrade; 4.5-in. Black Base, and 1.5-in. Sheet Top.

base in this section but the real merit of the type was not yet well established.

About a year ago an account of the first black base highway project in Illinois was published in this journal. Since that time numerous projects have been reported and other have been constructed. Some twenty miles of highway have been built in Michigan and further extensive yardages of pavements have been constructed in Clinton, Iowa, St. Paul, Minn., and Quincy, Ill.

At Decatur, Ill.

It will be the purpose of this article to recount developments in connection with the black base highway work at Decatur, Ill., in 1923, and discuss some of the details of the 1924 work at Quincy, Ill. The Brush College Road which was described in Municipal and County Engineering, October, 1923, was carefully observed during last winter when temperatures dropped suddenly to minus 24 degs. F. as well as during the past spring and summer months. In spite of a most unfavorable subgrade condition on a considerable portion of the project at the time of construction, the pavement is in perfect condition throughout its length with not a crack or even a very slight depression over the poor subgrade section.

Immediately after the construction of the Brush College Road last year, a section of identical black base was laid over a heavy fill at the approach to Nelson Park bridge, Decatur, Ill. The remainder of the Nelson Park Road project was sheet asphalt on Portland cement concrete base. Black base was chosen for the fill with deliberate intent, realizing that despite the fact that the fill had been in place about two years, it was almost sure to show further settlement due to the character of soil and the fact that the line of saturation would be high since it extended out into the lake.

Had Portland cement concrete base, employed elsewhere on the job, been used on the fill, it was feared a serious condition would result from settlement. On the other hand, it was thought that black base, even though it did depress wherever the fill settled, would most likely follow the subgrade down without rupture. Subsequent behavior confirmed the good judgment in selecting this type of construction. The fill did settle badly in spots and, as anticipated, the black base simply followed it and with a single exception of a short longitudinal crack in the center in the heaviest section of the fill, where heavy spring rains undercut the curbs badly, leaving the pavement edges entirely unsupported for a time, there is not a rupture to be found although some of the depressions formed are from 6 to 12 ins. in depth.

The economy of repair is at once apparent. If Portland cement concrete had been used, complete reconstruction of the entire fill section would have been necessary in the spring of 1924. The actual condition is such that repairs are limited to jacking up the displaced curb, rebuilding the eroded shoulders and filling the depressions with additional black base and sheet asphalt top and when this is done, the pavement will be as good, if not better, than it was originally. This case is cited as an excellent example of one of the prime virtues of black base construction, namely, its ability to maintain contact with the subgrade without rupture. In a district where heavy maintenance expense due to broken Portland cement concrete slabs prevails, this feature should receive serious consideration.

At Quincy, Ill.

All of the 1923 black base work at Decatur consisted of a 5.5-in. base and 1.5-in. sheet asphalt top. At Quincy, Ill., during the present year, some 45,000 sq. yds. of city pavement were laid on native subgrade, with a much larger program outlined for 1925. In all of this work the base was reduced to 4.5 ins. in thickness and it appears that this will be entirely adequate.

All of the subgrade, with the exception of one system of streets, was of native, yellow clay which contains some very fine sand. In dry weather this affords an excellent unyielding subgrade, readily susceptible to compaction by heavy rollers. In the one exception mentioned, the subgrade was made-soil, very loose in character. Unfortunately, during the construction of this system of streets, considerable rain occurred, creating a very serious hazard. On another street, namely East Broadway, a sewer had been laid in the spring and service trenches of various sorts were opened in advance of the paving. This offered another very serious hazard, even though considerable care was exercised in back-filling the trenches. As soon as the 12-ton 3-wheeled roller was applied to the subgrade, yielding areas were disclosed. These were excavated, refilled with broken stone and gravel and then capped with an extra

thickness of black base, usually about 6 ins. in addition to the 4.5-in. base specified. In all cases where this procedure was followed carefully, an absolutely firm subgrade was produced. In a few instances where the details were not carried out, it was necessary to go back and cut out small areas of the finished black base and make the necessary repairs. These instances, however, were few and could have been entirely avoided. In this particular project, further subgrade settlement over the trenches is not anticipated to any great degree; however, it was thought at the time black base was specified for the project that some settlement subsequent to the construction of the pavement might occur and again black base was selected with deliberate intent, realizing that the surface repairs in the event of settlement would be practically insignificant so far as expense of maintenance was concerned.

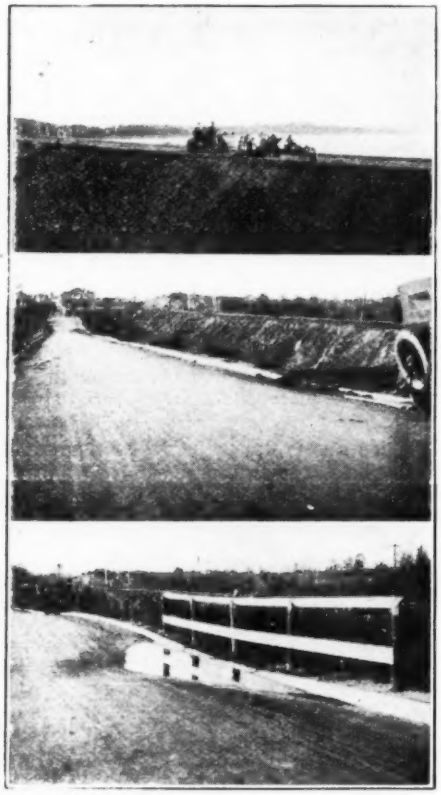
This particular feature of black base construction affords a very interesting point for discussion. One of the most frequent objections to black base construction for city work has been a hypothetical case wherein it is assumed that repairs to trench settlement would be difficult on account of the low bridging power of the black base as compared with Portland cement concrete. During the construction of this Quincy work, wherein numerous trenches were encountered, the bridging power of the black base caps over the trenches, when properly refilled was astounding, as in a number of cases these were tested with very heavy loads. Furthermore, there is a fundamental principle which applies in the case of loading black base slabs that is nearly always overlooked in comparing this type of construction with rigid types. It is true that a bituminous structure is susceptible to some distortion under constant loading; however, the same structure possesses very definite resiliency so that under momentary loading with immediate release of the load, as is the case with moving traffic, no permanent distortion results unless, of course, the load itself is greater than the inherent strength of the structure. The effect of this virtue under actual service conditions is obvious.

The black base was laid in one course as this was found to be much superior to the two-course construction. No difficulty was experienced with the hot mixture "pushing" on account of the thickness although it was found advisable to delay the application of top until after the base had cooled throughout. The mixture was so dense that surprising as it may seem, it almost assumed its final position when deposited on the subgrade and leveled off with the rakes. Very little impression was made by the rollers, either the heavy 3-wheeled or tandem types. Numerous tests of the base showed that surprisingly uniform mixtures were obtained as to composition and that the extreme denseness of the mixture extended from the top of the base to the subgrade. All the black base was laid according to the following plant formula:

Ac (pure bitumen)	35 lbs.
Sand	225 lbs.
Stone	540 lbs.
	800 lbs.

LAYING 4.5-IN. BLACK BASE ON EAST BROADWAY, QUINCY, ILL.

The sand used was ordinary Mississippi River pumped sand, such as is used for Portland cement concrete construction. The stone was local, crushed limestone, graded from a maximum of 2 ins. down to ¼ in. in size. Shipments of stone were observed primarily to insure satisfactory gradation in size from the maximum to the minimum without a preponderance on any one screen.



VIEWS OF BLACK BASE CONSTRUCTION ON NELSON PARK ROAD AT DECATUR, ILL.

Top: Shows Depth of Fill. Center: Frequent Dips Over Settled Subgrade without Surface Rupture. Bottom: Water 6-ins. Deep in Depression at Curb, but Slab is Unbroken.

1.5-in. sheet asphalt wearing surface was laid according to the following plant formula:

AC (pure bitumen)	93 to 95 lbs.
Limestone filler	250 lbs.
Sand	655 to 657 lbs.
	1,000-lb. box

A 10-ton, 3-wheeled roller was used for the initial rolling; an 8-ton tandem followed. Throughout the season's construction, including in addition to the black base work, about 50,000 sq. yds. of sheet asphalt resurfacing over old brick, the sheet mixture was remarkable for its uniformity and density.

This year's black base work at Quincy, Ill., also included the car track strips wherever these were encountered, with the black base carried to the bottom of tie, and sheet asphalt laid to the rails on both sides. Similar track paving was also employed at Decatur during the 1924 season. In connection with this work, it developed that the best way to construct the flangeways was to let the wheels cut their own grooves.

The cost of the black base work varied between $2.25 and $2.55 per sq. yd. complete, including grading. The average price for the season's work was $2.38 per sq. yd., which figure was also the bid price on a considerable portion of the work. This price is in direct comparison with $2.62 for Portland cement-concrete pavement including grading, laid by the same contractor who laid the black base.

A CRITICISM OF STREET PAVING PRACTICES

By Monroe L. Patzig, Manager Patzig Testing Laboratories, Des Moines, Iowa

My attention has been directed to a newspaper editorial entitled "Hard and Soft Paving." In it the statement occurs that a certain councilman has steered his city's paving program almost wholly to brick and concrete paving, and has abandoned the soft surfaced pavements. It goes on to give figures showing the change in five years as follows:

	Soft Sq. yds.	Brick and Concrete Sq. yds.	Combined Sq. yds.
1921	208,820.06	89,309.74	298,129.80
1922	119,763.6	35,533.05	158,296.65
1923	158,006.56	189,928.41	347,934.97
1924	58,965.00	378,165.00	432.130.00

Then it quotes the councilman as saying that 90 per cent of his repair work has been on soft surfaced pavements under 10 years old. Further it points out the seeming effect the automobile has had in creating this new paving situation, first by the heavy pressure on the soft surfaces, that most of them do not stand up under, and secondly, by the removal of the element of noise as an objection to hard surfaced pavements.

Another paragraph points out that the oldest soft surfaced pavement (about 24

years old) and another soft surfaced job (about 6 years old) have stood up well.

Its closing paragraph reads: "But, generally speaking the city is turning from the soft to the hard pavements, and apparently that is the trend everywhere." This editorial was published in a daily newspaper of a wide circulation, and such messages are therefore widespread.

Without any desire to defend or promote the interests of any type of paving surface, it occurs to me, however, that such articles are unfair to the public unless all facts have been determined and truthful statements of them made.

The public is interested in paving and is desirous of getting the most value for all expenditure. The public is eager to know as much as it can about pavements and does not wish to see its money spent for inferior types. For the welfare of the public, therefore, this editorial should be challenged.

Typical Paving Situation

One must first have a perspective of the paving situation as it exists in most of our cities. Few cities, indeed practically none of them, place the choice of design or kind of pavement in the hands of competent and reliable persons. Generally, the choice of types of paving is placed in the hands of city councilmen, aldermen or boards of public works. These men as a rule are elected to their offices from various walks of life, are seldom from positions or occupations giving them the experience in paving matters that the public expects them to have. As a rule their knowledge and experience are only equal to those of the public, yet their judgment is depended upon for perfect results.

There are few instances where the governing bodies have in their city's employ experienced men in paving matters upon whom they can or do rely for efficient guidance. There are numerous salesmen, and promoters of paving materials and types of pavement, who influence the engineers, councilmen, aldermen or those entrusted by the public to look after their paving construction. Most of them use every means possible to secure action favorable to themselves. Every promoter has theories in design tending to show his type superior to others. Officials without sufficient experience are attracted by the reasonableness of certain theories, even though they may be unimportant, impracticable or even erroneous. In fact there are so many pitfalls in choosing types, materials and securing proper construction that even the honest and conscientious officials will fall into them unless they have the proper knowledge and sufficient experience.

There are many reliable contractors whose work sometimes show defects caused by conditions not entirely their fault. They rely upon the specifications and supervision given them. They are not usually men who follow the technical or analytical phase of the work they construct. The cause for such defects to them are, oftentimes, just as puzzling as they are to the public or the officials entrusted with the city's business.

Now referring again to the editorial, although I have had no connection with paving operations in the city mentioned within the past twelve years, I have been a careful observer of its paving conditions and of the paving situation from time to time.

It has been my privilege to see the influence of politicians, material concerns and contractors interested in various kinds of pavements, rise and fall. This is more or less a typical condition in our American cities. Some have even worse conditions.

Investigations Necessary to Progress

While it is quite true that the city mentioned has experienced much difficulty in recent years with newly laid soft surfaced pavements, it was somewhat of a surprise to hear that 90 per cent of the repair work has been on soft surfaced pavements under 10 years old. Accepting the correctness of this statement, and agreeing that the situation seems alarming to the public, it appears that no conscientious endeavor has been made to determine the cause and set about the machinery to produce the right results.

That this is possible is evident from the fact that many miles of excellent soft surfaced pavements, with many years of service exist in this city as well as a hundred others. Likewise there are and have been in this city examples of concrete pavements that have been severely criticised on account of bad conditions shortly after having been laid. I have also seen brick paving replaced with other type paving within a few years after it was laid on account of its complete failure. The fact is that this city has excellent examples of each type of paving and it also has poor examples of each, the same as is experienced in many other cities.

Progress depends upon careful analysis of all defects and the correcting of over-

sights, neglect and poor judgment. The trouble is, there are always people without sufficient knowledge and experience ready to criticise before they have secured the facts. When defects are apparent they want to do something radically different, rather than secure the facts pertaining to that which was not satisfactory. In other words rather than find the cause and profit by it, they would rather try something else even though they know no more about it.

Later on when the type they thus choose proves faulty, someone will be ready to criticise that. Why not devote more attention to rectifying mistakes, and profiting by them, rather than to continue making errors and to work up the public ire on account of misleading statements?

The case here mentioned is one that has grounds for attention, but the defects encountered are not sufficient cause for condemnation. The same principle of condemnation as applied in this instance will be applied to the other types of paving mentioned in time, unless a more conservative attitude is taken in condemning without sufficient cause the work of others.

Referring to the relative decrease in yardage of soft surfaced pavements and the increase of brick and concrete constructed during the past four years, it is interesting to note that the year 1921 was under a previous administration in office; 1922 carried over uncompleted contracts from the previous year. The construction of the years 1922-1923 and 1924 have been under the present administration. Similar tabulations in other cities will undoubtedly show conflicting reports. Therefore the closing part of this editorial in which it says "apparently it is the trend everywhere to turn from soft to hard pavements," is unjust and misleading. Those who are familiar with paving conditions over the entire country know that there are many localities in which this statement would not hold true.

RESEARCH WORK TO IMPROVE ASPHALT PAVING MIXTURES

By Prevost Hubbard, Chemical Engineer, The Asphalt Association, 25 W. 43d St., New York, N. Y.

General practice in connection with the proportioning and preparation of asphalt paving mixtures, particularly those of the sheet asphalt type, has during the past 30 to 40 years become standardized to a high degree. This standardization has however, developed more from our knowledge of the composition and service history of old pavements than from a thorough understanding of the reasons for their satisfactory or unsatisfactory behavior. As a result our specifications are now filled with arbitrary limits which when met have, in the past, insured reasonably satisfactory results but which cannot be modified or improved upon to meet changing traffic conditions without becoming purely experimental.

Most of the older pavements upon which our ideas of satisfactory composition have been based were constructed under conditions, and during their early life were subjected to traffic, materially different from the conditions and traffic which prevail today. It is quite reasonable therefore to assume that the ideal paving mixture of 30 years ago is not necessarily the best to use at present.

Two Types of Failure

There are two principal types of failure to be guarded against in the construction of an asphalt pavement—cracking and shoving. In the early days of the asphalt paving industry the former was perhaps the most troublesome and received the most attention. Today shoving or displacement under traffic, while by no means of universal occurrence, is undoubtedly the biggest problem with which we have to contend.

The old pavements were constructed with a relatively light initial compression of the hot paving mixture and for many years after construction most of them were subjected to moderate horse drawn traffic which ultimately brought the mixture to its maximum practicable density without undue distortion or displacement before it was subjected to the rapidly increasing volume and weight of the motor driven traffic of today. During this period the mixture also hardened with age and its stability was thereby increased.

Modifications Advocated

At present we construct our asphalt pavements one day and the next open them up to a volume and weight of motor traffic which was never even remotely anticipated when the composition of paving mixtures was well advanced in the process of standardization. Under such conditions it is not at all surprising that shoving and rutting are of more common occurrence than heretofore. That this trouble is not even more prevalent

is probably due to certain modifications in paving practice which are now being advocated and followed to a considerable extent. Among the most important of these may be mentioned, the demand for more thorough initial compression, the use of more mineral filler and relatively less asphalt in the paving mixture, and the use of harder grades of asphalt than were previously thought most suitable.

There can be no question about the desirability of obtaining maximum initial compression of the hot mix although the best method of securing results has probably not yet been developed. With regard to modifications of the mix itself, while indications point strongly to the soundness of the present tendencies that have been mentioned, there is no accepted method of determining the limitations of such modifications nor their interrelationship. The same is true regarding modification of our arbitrary limits of mineral aggregate grading.

Need for Laboratory Test

It has long been recognized that great need exists for some suitable laboratory test to determine the stability of asphalt paving mixtures and considerable thought has been given to the development of such a test by a number of testing engineers. It is believed that the use of a test of this nature will more rapidly solve our paving problems than any other line of attack and will be of the greatest assistance in our analysis of the service results of old pavements and comparatively new experimental pavements. Time will not permit of a discussion in this paper of the work of various investigators along this line but it should be noted that there is at present no generally accepted method of determining by laboratory test the degre of stability possessed by a sample of compressed asphalt paving mixture.

A Simple Stability Test

During the past few months the author with very limited resources for conducting laboratory research was able to arrange for a certain amount of experimental work leading to the development of a simple stability test. For the actual performance of this work and for many helpful suggestions pertaining thereto credit belongs to Mr. F. C. Field of the Asphalt Association. It is felt that the results so far obtained while of a preliminary character have proved sufficiently interesting and promising to warrant their presentation at this time. It should be understood, however, that the work so far accomplished is only a beginning and that it would be extremely unwise to draw any definite conclusions regarding paving practice from the results here reported. Much more data of an experimental nature must first be secured. With this understanding we may proceed to a consideration of the method of test which has been devised.

Failure by Shoving

If we consider for a moment the mechanism of shoving where it has occurred in asphalt pavements we note first of all that this type of failure is caused by inability of the paving mixture permanently to resist the thrust of traffic as delivered by loaded wheels in motion. While occasional exceptions are to be noted, the movement of the displaced paving mixture is generally in the direction of traffic and is therefore not due to the sudden backward push of the driving wheels of motor vehicles. It is rather due to the sliding or shearing stresses set up between the mineral particles which results in their rearrangement and forward movement under compression as the heavy wheels move forward.

While impact is undoubtedly an important factor which rapidly accelerates shoving once it has gotten well under way, it is believed that shear is the primary cause of shoving. In addition it has been repeatedly noted that shoving commences most readily and progresses most rapidly during hot weather when the asphalt binder is most plastic. It would appear therefore that any test for determining resistance to shoving in a paving mixture should in some way measure its resistance to internal rearrangement of its mineral particles at the maximum temperature to which it is likely to be subjected under service conditions.

Apparatus Used

The apparatus which was used in making our tests is a simple one consisting of a cylindrical steel mold about 5 ins. high with an internal diameter of 2 ins. The bottom of the mold has a circular bevelled opening smaller than the internal diameter of the mold, thus producing a shoulder which holds the specimen in place. This opening may be closed with a bevelled plug as shown in Figure 1. The mold is equipped with a snug fitting plunger for compressing the specimen to be tested and for applying the testing load. In preparing a specimen for test, about 210 grams of the hot loose paving mixture is placed in the preheated mold with the bottom closed by the plug. The

plunger is then inserted and the apparatus immediately placed in a small compresion machine where the mixture is compressed under a load of 4,000 lbs. (about 1,275 lbs. per square inch) or approximately that obtained under the usual tandem roller.

This produces a cylindrical briquette 2 ins. in diameter and approximately 2 ins. high. With the crude outfit available it was impossible to remove the briquette without injury or distortion so it was found necessary to test it before making up additional specimens. The mold and its contents were therefore cooled and then placed in an oven at 160 deg. F. for two hours so as to insure it being uniformly heated throughout. The apparatus was next placed in the compression machine with the plug removed from

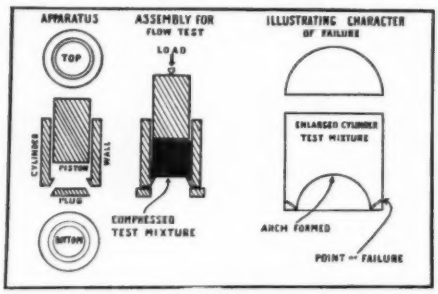


FIG. 1.

the bottom of the mold which was elevated to allow free movement of the mixture through the aperture. Load was next applied to the plunger in small increments until the bond of the compressed mixture was broken and it began to exude from the bottom opening. This point is quite definitely indicated by a falling off in the load as the plunger moves downward with the exuding mixture. Bottom openings of various diameters were experimentally tried and at first numerous attempts were made to measure the rate of flow of various mixtures under a constant load. After a great deal of experimenting, however, it was finally decided to adopt the 1¾-in. opening and measure only the load required to break the bond in the compressed mixture.

Testing

With care and attention to all details of preparing test specimens it was found possible to secure reasonably close check results usually within 5 to 10 per cent of the total load. It was also found that different mixtures showed a wide range of stability as indicated by the test. During the early stages of the investigation, in order to save time in the laboratory, a large sample of paving mixture was taken from a local paving job and test specimens prepared from this sample. After a portion had been tested with very satisfactory check results further tests proved so erratic as to cast doubt upon the accuracy and value of the test. Investigation, however, disclosed the fact that in taking the large sample we had happened to hit upon a poorly mixed load which varied sufficiently in composition, as determined by analyses of the test specimens, satisfactorily to explain the apparent discrepancies in test results.

An Interesting Discovery

The character of failure in a test specimen produced by the test which has been dscribed is of particular interest because its discovery led to a development in our investigations which it is believed will be of great assistance in our study of paving mixtures. Examination of briquettes which had been tested showed that failure was produced by shearing or sliding stresses operating through a conical area extending from the edge of the circular opening to the wall of the mold as shown in the illustration.

Moreover, a pronounced arch invariably developed at some height directly over the bottom opening due undoubtedly to interlocking of the mineral fragments of the mixture. This last suggested the idea that the test might possibly be adapted to an investigation of the relative mechanical stability of mineral aggregates without reference to the cementing medium. If so our problem would be simplified by permitting us temporarily to eliminate one of our most important variables, namely, asphalt, and to secure a great deal of preliminary information which would guide us in our future study of the complete mixture.

Testing Sand

Acting upon this suggestion various methods of testing sand without a binder were tried. To prevent segregation during manipulation it was evident that the sand would have to be mixed with some sort of a liquid, preferably a viscous liquid, but one which was non-cementitious in character. Various materials were tried and finally castor oil was selected as being the most promising. It was found that briquettes composed of a mixture of sand and castor oil could be quickly made and tested at room temperature with the apparatus previously de-

scribed and that very close check results could be obtained, usually well within 5 per cent of the test value, when a standardized procedure was followed. The castor oil appeared to act as an agglutinating lubricant which when used in suitable quantity permitted the sand grains to find a favorable position for interlocking and after the interlocking bond was formed possessed no true cementitiousness to reinforce that bond. For the sand-castor oil mixtures, however, it was

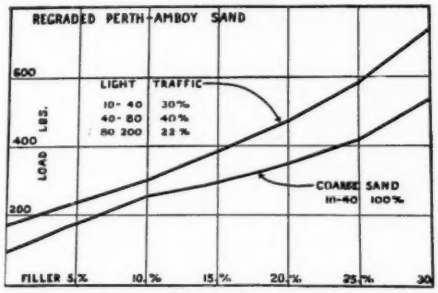


FIG. 2.

found most desirable to adopt a mold with a bottom opening 1½ ins. in diameter.

A quantity of Perth Amboy sand, which is extensively used in asphalt paving in New York City, had been secured for our experimental work and from which this supply sands of various mesh composition were obtained by screening and recombining. When mixed with castor oil and compressed and tested in the mold these sands showed considerable difference in their ability to resist displacement. Mineral filler was then added to the sands in increasing amounts and its effect upon the stability of each sand product determined. A commercial limestone dust was used for this purpose which upon examination was found to contain 66.5 per cent passing the 200 mesh sieve.

Test Results

From the results obtained diagrams were constructed showing the load causing failure for each sand grading tested, as the per cent of mineral filler in the mixture was increased. Such a diagram showing the results obtained with a typical light traffic grading and a coarse sand is illustrated in Fig. 2. It will be seen that without filler the coarse sand showed a strength of approximately 95 lbs. as against 175 lbs. for the better graded sand. The stability of both products is materially increased by successive additions of filler but in no case is the strength of the coarse sand equal to that of the graded sand with the same amount of filler. For instance, the light traffic sand with 10 per cent of filler shows a strength of 300 lbs. which is not reached with the coarse sand until about 17 per cent of filler has been added. It will also be noted that while the strength of the two sands tend to come closer together up to 10 per cent filler, they diverge more rapidly beyond that point.

Surface Tension

Early in our work it was realized that although the agglutinating agent, castor oil, which we were using to hold the sand grains in place possessed little or no cementitiousness, the surface tension of thin films of any liquid which could be used might exert considerable influence upon our stability tests and under certain conditions give us misleading results. It was therefore necessary to either eliminate this factor or reduce it to a standard where the relative effect would be the same for all mineral aggregates which it was desired to study.

With this object in view a set of tests was run on widely different mineral aggregates mixed with various amounts of castor oil. The results of these tests are illustrated in Figure 3 where a comparison is shown of the effect of varying the percentage of oil on a sand without filler, the same sand with 13 per cent mineral filler, and a pure limestone dust filler.

For the straight sand without filler it is seen that the percentage of oil between

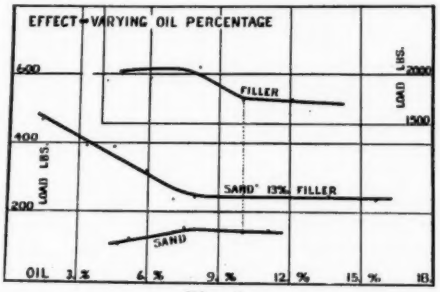


Fig. 3

the limits used has little effect upon the stability of the sand and that with from 7.5 to 11.0 per cent the load causing failure is practically constant. With the sand containing filler and with the filler alone the effect of greater surface area, with a reduction in thickness of oil film is apparent, where relatively small amounts of oil were used. The effect of surface tension of the thinner oil films

is at once seen in the higher strength of these mixtures. Fortunately, however, in both cases we found that with 10 per cent or more of oil the results became practically constant for all mixtures and it was therefore decided to use 10 per cent of castor oil in all of our sand mixtures.

In connection with this diagram it is particularly interesting to note the very high degree of stability possessed by the

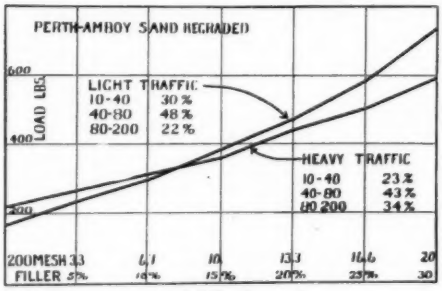


FIG. 4.

limestone filler which with 10 per cent oil shows about 1,750 lbs. as compared with 150 lbs. for the sand alone and 250 lbs. for the sand mixture containing 13 per cent filler.

Testing Common Standards

In common asphalt paving practice two supposedly ideal sand gradings have been set up as standards to be approached as closely as possible, one for light traffic and one for heavy traffic. It was thought that it would be of considerable interest to subject these two standard gradings to our stability test to ascertain what sort of a comparison would be developed. The Perth Amboy sand was therefore screened and recombined to produce the two desired gradings and tested with the addtion of various percentages of limestone filler in a 10 per cent castor oil mixture. The results of these tests are shown in Figure 4 in which the lower figures along the base line indicate the percentage of limestone used and the upper figures the actual percentage of 200 mesh particles in the mix.

Here it is seen that while the heavy traffic grading shows the higher initial strength, the two gradings with 12 per cent dust show an equal strength, and as the percentage of dust is further increased the light traffic grading shows an increasingly greater strength as compared with the heavy traffic grading. With the amount of filler used in present day mixtures it would therefore appear that our so-called light traffic sand is better adapted to heavy traffic than our so-called heavy traffic sand. This indication is borne out to some extent by the generally excellent results obtained under heavy traffic in New York City with natural Perth Amboy sand which has a grading much closer to the ideal light traffic sand than to the heavy traffic sand.

The next diagram, Figure 5, shows comparative results obtained with uniformly coarse, medium and fine sands and the well graded light traffic sand. The coarse sand was all retained on the 40 mesh sieve and the fine sand free from 200 mesh particles all passed the 80 mesh sieve. The medium sand all passed the 40 mesh and was retained on the 80 mesh sieve.

Effect of Mineral Filler

It will first be noted that in every case the initial strength or stability of the sand is increased by the addition of mineral filler although such increase is not by any means directly proportional to the amount of filler added. At a number of points two curves are found to intersect and at some apparently critical points the further addition of a small amount of filler appears to increase the stability of the sand much more markedly than at other points.

An interesting relation is shown by the heavy horizontal line which points out the amount of filler required by each sand to produce a stability equivalent to the light traffic sand with 15 per cent of filler. In this connection it should be noted that 15 per cent of filler represents 10 per cent of 200 mesh limestone dust. Thus to attain this degree of stability the fine sand requires 13 per cent of filler and the medium and coarse sands 20 and

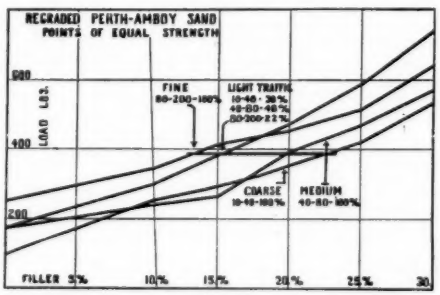


FIG. 5.

23 per cent respectively. It is further seen that to equal the light traffic sand with 20 per cent filler or 16.6 per cent 200 mesh material all of the other sands would require a higher per cent of dust.

Sand Grading

In the first part of this paper reference

was made to the arbitrary limits of sand grading embodied in most specifications for sheet asphalt. If we consider an asphalt sand as being composed of three groups of sand grains it is possible to indicate the grading of any sand with a single point by means of a triaxial diagram. It is also possible on such a diagram to locate an area bounded by the ordinary specification limits within which all acceptable sands must fall if their acceptability is based upon the relative quantities of the three groups of sand grains. Bearing in mind that sheet asphalt mixtures are always required to contain mineral filler and that our tests had indicated a general, but not directly proportional, increase in stability of all sands with an increase in percentage of filler it was thought desirable to test out

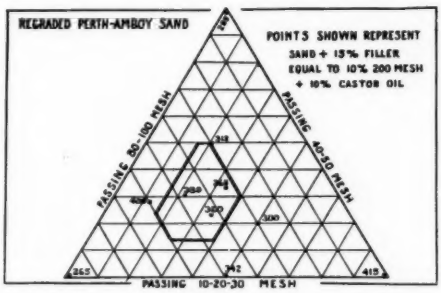


FIG. 6.

our specification limits for sand grading as indicated by the triaxial diagram. For this comparison ten sands of different composition were plotted on the triaxial diagram. The strength that each developed under the stability test when mixed with the same amount of filler was then noted in its proper position on the diagram.

Figure 6 shows the stability values obtained for each of the sands after it had been mixed with 15 per cent filler, equivalent to 10 per cent of 200 mesh limestone. Within this diagram the area enclosed in heavy black lines covers all sand gradings admitted under our present specifications. So far as comparative values are concerned it would seem that while our present specification limits are safe they are entirely too restrictive. While it is true that out of the five highest values three fall within the specification area and of the other two one represents a sand which would probably seldom occur in natural deposits, nevertheless the next to the highest value is shown by a sand outside of the specification area. I refer to the point labelled 400 which indicates the natural grading of Perth Amboy sand.

Similar comparisons of these sands with other percentages of filler were also made by means of the triaxial diagram. While the test values were of course different in each case the same fact was indicated, namely, that while our present specification limits are safe they are unnecessarily restrictive.

Difference Between Sands

It has been stated that very close check results could usually be obtained by the stability test on mixtures containing castor oil, the differences ordinarily being well within 5 per cent of the test result. In the diagrams which are shown each point from which the curves were plotted represents an average of from three to five individual tests. In view of this apparent degree of accuracy it was thought that the test might be used to distinguish differences between different sands of the same mesh composition.

To aid us in such a determination we happened to have at hand a sample of well graded sand from Cheraw, North Carolina, with grain surfaces much smoother, and known by experience to satisfactorily carry less asphalt, than the Perth Amboy sand. In order that differences in mesh composition should be eliminated to the maximum extent, samples of the Perth Amboy and Cheraw sands were carefully screened and each recombined in the exact proportion to produce the complete mesh composition of the ideal light traffic grading. These products were then tested with varying amounts of filler in castor oil mixtures with results shown in Figure 7. Here it will be seen that while the two sands parallel quite closely throughout the series of from 0 to 30 per cent filler, the Cheraw sand gave results consistently lower than the Perth Amboy sand. It is evident therefore that the stability test is capable of indicating a measurable difference between sands of the same mesh composition but of different surface texture or perhaps grain shape.

Tests of Mineral Aggregate Only

So far all of the test results presented have had to do with the mineral aggregate only. While the method was conceived for the purpose of determining the stability of paving mixtures containing asphalt and while most of the preliminary work was devoted to such mixtures no complete series of tests with asphalt as a binder have as yet been made. In order to conduct such tests with reason-

able speed and efficiency some slight changes will be required in the design of the mold so that specimens may be removed without injury immediately after compression and brought to the temperature of test in batches after which they must be tested under conditions which will insure maintenance of a constant temperature throughout the test. It is believed that these details may be cared for without difficulty but for reasons previously discussed the present investigation was confined mainly to a study of mineral aggregates. A few results were, however, obtained with asphalt mixed with natural Perth Amboy sand which are of considerable interest in connection with the data already presented. These are shown in Figure 8.

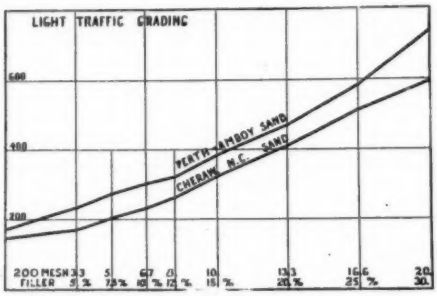


FIG. 7.

It will be remembered that the natural Perth Amboy sand has for some time past been extensively used in asphalt paving in New York City and vicinity and shows approximately the following grading: Passing 10 and retained on 40 mesh, 26.5 per cent; passing 40 and retained on 80 mesh, 60.5 per cent; passing 80 and retained on 200 mesh, 11.5 per cent; passing 200 mesh, 1.5 per cent. In Figure 8, the lower black line shows the stability values of this sand in a castor oil mix with various amounts of limestone dust filler. Directly above it appears a line indicating the results obtained with the same sand mixed with from 6 to 12 per cent filler and 10.5 per cent asphalt. The tremendous increase in stability due to the presence of the asphalt cement is at once apparent. In this connection it should also be remembered that the castor oil mixtures were tested in the mold with a bottom opening 1½ ins. in diameter while the asphalt mixtures were tested in the mold equipped with a bottom opening of 1¾ ins. diameter. Had the 1½-in. opening been used for the asphalt tests a much greater increase in stability would have been shown. The value, however, would have exceeded the capacity of our compression machine and therefore could not be ascertained.

Increasing Stability

It is of particular interest to note that the addition of filler to the asphalt mix materially increases its stability as in the case of the castor oil mix. While the actual increase in stabiilty of the former is greater for a given amount of filler it so happens that the relative increase is almost directly proportional. Thus at 6 per cent filler the castor oil mix shows a strength of 233 lbs. and at 12 per cent filler 342, an increase of about 47 per cent. The asphalt mix with 6 per cent filler shows 800 lbs. and with 12 per cent filler 1,200 lbs., an increase of 50 per cent. The relative increase of 47 per cent and 50 per cent are so close together in this individual instance as to make it highly desirable to ascertain whether such a direct relation is to be expected in other comparisons.

In the line at the right of Figure 8 is shown the effect of varying the percentage of asphalt in admixture with the same sand carrying 12 per cent of limestone dust. The marked decrease in stability due to increasing the asphalt from 10.5 to 12.5 per cent is at once apparent. Thus an increase of asphalt of 2 per cent over what might be considered as the normal amount has cut the stability value in half. The great importance in ascertaining the correct amount of asphalt for a given mineral aggregate and then holding this amount within very narrow limits is thus plainly indicated. For the particular set of tests here shown it would appear that the use of 1 per cent too much asphalt would offset the advantage to be secured by the addition of approximately 5 per cent of filler.

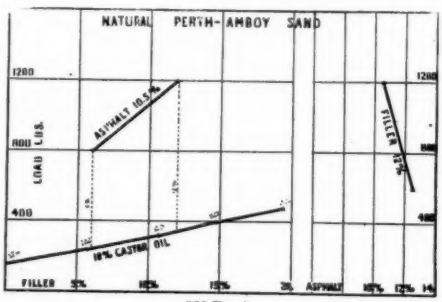


FIG. 8.

Some General Results of Tests

It is of course unwise at this stage of our investigation to attempt to develop

definite theories or to interpret our test results too literally. It is felt, however, that a method has been devised which, if intelligently used, will enable us to secure a vast amount of information leading to the development of more stable asphalt pavements than we have heretofore secured. The test which has been described gives promise of furnishing valuable data on many questions relating to asphalt paving mixtures which heretofore have been matters of individual opinion or purely arbitrary treatment. Among the most important of these are:

1. The importance of sand grading requirements and the rational limitations of such requirements to adopt.

2. The relative value of different kinds of mineral filler, such as limestone, slate, silica, hydrated lime and Portland cement.

3. The proper proportioning of asphalt with different mineral aggregates to secure adequate resistance to displacement.

4. The effect of consistency and other properties of asphalt upon the stability of paving mixtures.

5. The possible adoption of definite stability limits of paving mixtures as determined by test which will undoubtedly allow a much wider use of available local materials and thus tend to reduce the cost of asphalt pavements and at the same time insure greater stability.

In connection with the last item mentioned it is believed to be quite feasible to adapt the stability test to general use at asphalt paving plants as well as in regular testing laboratories and complete equipment suitable for such use is now being devised. We hope to continue our investigations as rapidly as possible and within a short time be able to present a mass of data which will definitely prove whether or not the test will be of as much assistance in solving our shoving problem as it now promises to be.

Summary

To sum up this matter in a few words for the benefit of the layman who has neither time nor inclination to consider technical details it may be pointed out that at present we have methods for determining the penetration and numerous other physical and chemical characteristics of asphalt and methods for determining the grading of sand, filler and other mineral aggregates. No matter how intelligently such tests are made and used, however, they do not necessarily insure the most stable mixture when the various materials are combined and yet stability is the primary requisite of an asphalt paving mixture. The very great benefit to be derived from a simple test for stability is therefore clearly apparent. If such a test can be made available for use at a paving plant and specifications are so drawn as to admit a wide variety of products provided that when combined the mixture will have a certain stability value as determined by test, the contractor and engineer will be able to ascertain in advance what particular combination will produce the most satisfactory results. He will also have a wider choice of materials from which to make his selection because our present arbitrary and restrictive requirements can safely be broadened to include many products which are now eliminated by our specifications. It would therefore often be possible to obtain not only a better pavement but a cheaper one as well.

The foregoing paper by Mr. Hubbard was presented at the Third Annual Asphalt Paving Conference, held at Louisville, Ky., Oct. 13, 1924.

NOVEL CONSTRUCTION OF CONCRETE FOUNDATIONS FOR STRUCTURES

By W. G. Kirchoffer, Hydraulic and Sanitary Engineer, 22 N. Carroll St., Madison, Wis.

This paper briefly describes a method of constructing reservoir walls and foundations for small dams, bridges, chimneys, etc., in locations where the materials to be excavated are water bearing sands and gravel, quick sand or other materials which will not be self-supporting and would require complicated or expensive sheeting and bracing.

Use of Cutting Shoe

For many years large, round wells and storage reservoirs have been constructed of brick or stone masonry built upon a wooden or steel cutting shoe. Either all or a portion of the excavation of the dry material, if any, above the wet or soft material usually has preceded the beginning of the masonry work. Then the shoe is laid in place in the bottom of the excavation and as excavation has progressed the shoe with its wall above are allowed to settle, the wall being carried up as fast as the sinking takes place. In such construction, great care had to be exercised to prevent the cracking of the walls due to stresses developed by unequal settlement. These walls and reser-

voirs often had to be abandoned or were relatively expensive on account of this bad feature.

Adapting an Old Method to Modern Materials

Since reinforced concrete has come into general use and can be substituted for the brick or stone masonry, the cracking of the walls, due to unequal settlement, is largely eliminated. By the adoption of reinforced concrete for the walls of wells and reservoirs, to be constructed wholly or in part below ground, very simple inexpensive forms may be used, and the steel or wooden shoe eliminated. In my work I have usually made the forms of 1-in. matched flooring nailed vertically to horizontal ribs of two thicknesses of 2-in. plank. The inside form braces itself and the outside form may be held by two rods or cables with turn buckles.

When the surface material is solid for 5 or 6 ft. the excavation usually precedes the starting of the wall. Then the forms and reinforcing materials are placed in the excavation and a ring of concrete is poured. This is usually allowed to set for a day before removing the forms or starting the excavation again.

Reservoir Construction

As the excavation is carried down, the walls will sink and the forms may be placed again at the top of the completed portion and again filled. This process can be carried on until the desired depth is reached. Where large quantities of water or quick sand are encountered, it will of course be necessary to use a power pump continually. Reservoirs built after this method were successfully and economically constructed at Munising, Mich., Medford, Marshfield and Shawano, Wis. The materials excavated varied from water bearing sand to boulder clay. The diameters were 35 to 50 ft and the depths ranged from 15 to 25 ft. It was the success of this method on the above mentioned reservoirs and wells that caused the writer to use the same method for constructing the foundations to a small dam and furnished him an excuse for writing this brief paper.

On Dam Construction

The Viola Light & Power Co. desired to construct a concrete dam about 200 ft. long and 8 ft. high upon the Kickapoo River at Viola, Wis. It was necessary, on account of the size of the job and the remoteness of the place, to do the work by force account and as cheaply as possible. For these reasons and because of the small amount of equipment available, the writer adopted the same method of construction for the foundation as he used on the reservoirs, except that in place of making the forms circular, they were made to enclose a rectangular wall 12 ft. long, 8 ft. wide, 6 ft. high and 1 ft. thick. These forms were made of 2-in. plank in a substantial manner, so that they could be used several times. The concrete was reinforced with ½-in. round rods, spaced 1 ft. vertically and 3 ft. horizontally. The water in the river was from 1 to 3 ft. deep.

The work was begun on the flats along the river and as excavation progressed, only the dirt was used for coffer dam about the forms. These rectangular sections were constructed end to end as they were sunk, and as soon as the top of one came close to the top of the water, another section was poured on top of it until a total depth of 12 ft. below the river level was reached. The material to be excavated was sand, gravel and clay with some old logs and slabs scattered through it. The openings between the cribs or sections were closed by pouring concrete in the V-shaped openings left at the ends. The space within the wall was filled with gravel, stone and clay. The whole foundation, including an apron in front of the dam was then covered with a slab of concrete 18 ins. to 2 ft. thick upon which the dam was to be constructed.

This method appeals to me as being very practical where a full contractor's equipment is not available and work must be done at a minimum of cost and with inexperienced labor. It has the advantage of being cheap, saves time, eliminates many dangers of open excavation held by curbing and bracing, is effective and easily put in by men of little experience in construction work. It would seem to be a very practical method to use for the construction of not only circular reservoirs and small dams, as mentioned herein, but for small bridges, chimneys, monuments and other foundations where the ground is soft or where it is desirable to eliminate the use of a large amount of lumber for forms. ,

I am unable to give any cost figures on this method as nearly all of the pieces of work were carried on in conjunction with other work and the cost was not separated. Some engineers might find objection to the method because it is quite difficult to design a wall to take the stresses put upon it in this way, especial-

ly so with circular reservoir walls. I never have attempted the use of very much mathematics on my designs but have used what little horse sense I had, on the theory that $100 of my employer's money was better spent in steel and concrete than in questionable theories of unknown and undeterminable stresses.

PRACTICE OF VARIOUS CITIES WITH RESPECT TO PAVEMENT OPENINGS

By D. S. MacBride, Formerly District Engineer, Portland Cement Association, Philadelphia, Pa.

(Editor's Note: Following is the text of the report on the questionnaire on Pavement Openings, made by Mr. MacBride at the conference on the administration of city paving departments held at the Engineers Club of Philadelphia on Feb. 20, 1924, and reported in the September, 1924, issue of "Engineers and Engineering," the official journal of the club. Mr. MacBride is a member of the Highways Committee of the Philadelphia Chamber of Commerce.)

The investigations which the Highways Committee of the Philadelphia Chamber of Commerce have conducted into the physical as well as the administrative problems which confront officials charged with the maintenance of city paving, have convinced that committee that one of the most difficult of these problems is connected with the control of service openings. The difficulties seem to arise through a lack of appreciation of the importance of this work by the legislative department of our city governments. In few cases is the proper machinery set up through which the highway executive can properly control the execution of and the methods used in making and closing openings in city pavements.

In order to gain information the committee circulated a questionnaire among the principal cities of the country. This questionnaire was suggested by an official experienced in the administration of city paving problems and is as follows:

Questions Asked

1. What charges are made by the city for permits to open streets?
2. What disposition is made of the funds collected by the city from such permits?
3. By whom is the physical work of making the opening done?
4. By whom is the work of backfilling the trenches done?
5. What supervision does the city exercise over the work of backfilling?
6. What steps are taken toward the temporary paving of the ditches pending the replacement of the permanent paving?
7. What means are adopted to strengthen the pavement laid across the area occupied by the ditch?
8. By whom is the permanent paving restored?

The method of gathering the information was to utilize the national organization with which the speaker is connected, sending out the questionnaire with the request that the required information be obtained from the principal cities in point of population throughout the country, as well as from any smaller cities which handle this problem in an unusually creditable manner. No claims are made for the answers to this questionnaire as being representative of the average practice throughout the country, but this summary is submitted for whatever it may be worth in showing to whatever extent it may reveal the practice which obtains in the cities listed below. In all but a few cases the answers to the questions were sufficiently clear and explicit so that little fear is held that any great proportion of misstatement or error exists in the tabulation. It is inevitable, however, that some slight inaccuracies have crept in which can be pointed out in the discussion of this paper without danger of offending the speaker.

Cities Replying

Replies were received from 33 cities which vary considerably in both population and importance from thriving midwestern centers of population to the great eastern metropolis. The list of cities is as follows:

New York—Manhattan, Bronx, Richmond, Brooklyn, Queens, Yonkers.
Maryland—Baltimore.
Massachusetts—Boston.
West Virginia—Parkersburg.
Pennsylvania—Philadelphia, Pittsburg, Newcastle, Erie.
Oregon—Portland.
Missouri—St. Louis.
North Dakota—Sioux Falls.
Ohio — Mansfield, Sandusky, Youngstown, Cleveland, Springfield, Columbus, Cincinnati, Dayton.
Michigan—Detroit.
District of Columbia—Washington.

Minnesota—St. Paul, Duluth.
Illinois—Champaign.
Washington—Seattle.
Alabama—Birmingham.
Indiana—Indianapolis.
Arkansas—Little Rock.

An attempt has been made to summarize the answers to these questions as briefly as possible. While it is true that all of the points which could be made are not brought out through this method, I believe that a full presentation of these data in tabular form would be more confusing than valuable.

Charges for Permits

The handling of the costs in connection with the opening of streets is summarized in the following manner: Three of the cities in this group make no charge for the granting of a permit for the opening of a city pavement. In Columbus and Duluth it is reported that the city and public utilities control all underground structures and make all necessary openings. In Sioux Falls no control is exercised, the replacement of the pavement being made at city expense. In two instances the only charge is a fee for the clerical work incident to the issuance of a permit which is $1 in the case of Mansfield and $7 in Newcastle. No mention is made of the method of assessing the costs of pavement replacement in Mansfield. Newcastle requires a bond under which the permit holder replaces the pavement.

In 12 cities a flat charge is made to cover the anticipated expense connected with the repair of the pavement opening. In two instances the amount of the charge is independent of the size of the opening being $20 in the case of Philadelphia and $3 in Erie. This flat charge is varied with the size of opening and in some cases type of pavement in the following 10 cities: Brooklyn, Indianapolis, Cleveland, Springfield, Cincinnati, Baltimore, Yonkers, Pittsburgh, St. Louis and Detroit.

In 16 cities the actual cost of the replacement is collected from the permit holder or the property owner. In the case of Manhattan, Queens, Sandusky and Washington a cash deposit is placed with the city, from which the actual costs are deducted. The balance remaining is either returned to the permit holder or allowed to remain in a standing deposit which he maintains with the city. The Bronx requires a cash deposit of from $30 to $50 which is retained, collecting the excess cost from the permit holder after the completion of the work. In 9 cities the permit holder is billed for the actual cost; the pavement of which is in most instances secured by either a bond or a cash deposit. These cities are Richmond, Youngstown, Birmingham, Portland, St. Paul, Seattle, Dayton, Little Rock and Champaign. While Boston and Parkersburg collect the actual cost from the permit holder. The information at hand is not sufficient for the proper classification of these cities. It may be interesting to note that in 11 of the 33 cities a charge is made for the clerical work incident to the issuance of a permit. In most cases this charge is quite nominal and is usually independent of any costs which may be connected with the work involved.

Disposition of Funds

An analysis of the answers received regarding the disposition which is made of the funds collected by the city from permits, shows that in 18 cities no balance reverts to the city for the reason that the unused portion of the deposit is returned to the permit holder. Without practical exception the used portion of these funds are at the disposal of the Highway Department, as in the case of Manhattan, Sandusky, Bronx, Washington, Queens and Detroit or that the permit holder is billed for the cost as in the case of the borough of Richmond, Youngstown, Birmingham, Parkersburg, Sioux Falls, Portland, Dayton, Little Rock, St. Paul and Champaign. No funds are available in either Columbus or Duluth because the city or the public utilities do all work of this kind according to the information available.

In 6 of the cities the permit money is deposited in funds other than those reserved for highway purposes, which is the general fund in the case of Indianapolis, Philadelphia, Boston, Erie, Newcastle, Pittsburgh.

Nine cities, Brooklyn, Cleveland, Springfield, Seattle, Mansfield, Cincinnati, Baltimore, Yonkers, place the revenues arising from the issuance of these permits in separate accounts for the repaving of pavement openings which in some instances produce a self-sustaining department. In Birmingham they are used to defray the cost of inspection.

The information submitted in the case of St. Louis is not sufficient to properly classify that city in this connection. It will be observed that Birmingham is

mentioned twice in the above connection which arises from the fact that the practice which obtains in this city falls under more than one of the classifications which have been made under this heading.

Who Makes Opening?

The analysis of the replies is less involved than those which have gone before. It is found that the permit holder performs the physical work of making the opening in 30 of the cities while in Dayton and Duluth this work is performed by the city and in Columbus by the city or public utilities involved.

Backfilling

The backfilling of the trench is performed by the permit holder in 25 of the cities, by city forces in 6 of the cities, Mansfield, Seattle, Dayton, Duluth, Little Rock and Champaign. The city or the public utilities performs this work in Columbus and Detroit.

Due to the important relation which exists between the method of making the backfill and the future condition of the pavement over the trench, a question was included tending to disclose the amount of supervision which the various cities tried to exercise over the backfilling operation. It is found that five of the cities make no attempt to inspect this work. In 4 of these cities, however, the municipality is protected against loss through the posting of a bond as in the case of Youngstown or by a cash deposit in Springfield, Cincinnati and Washington. No financial protection is given the city in Sioux Falls. Inspection intended to cover all classes of work is provided in 19 of the cities. No attempt has been made, however, to evaluate the effectiveness of this inspection. A system of corporation inspectors is employed in 4 of the cities which in the case of Manhattan and the Bronx is supplemented by a force of city inspectors for miscellaneous openings. In Detroit work on other than public utility openings is performed by city forces, which is deemed sufficient inspection in that case, while Brooklyn provides no inspection other than the corporation inspectors referred to.

Inspection

The backfilling operation is inspected by a city force in Indianapolis, Columbus, Parkersburg, Portland, Erie, St. Louis and the borough of Richmond, the cost of which in the case of the last named city, is charged against the permit holder.

In Queens, Birmingham and Newcastle, the city inspects the backfill after completion, while Sandusky provides continuous inspection for the entire operation of cutting, digging, backfilling and repaving of all openings.

The cities of Baltimore, Yonkers, Boston and Pittsburgh attempt to inspect all openings but due to lack of funds principally, this inspection is admitted to be quite casual.

Philadelphia and St. Paul have a corps of city inspectors which are used entirely on the openings made by public utilities. This holds true in the case of Cleveland with the addition that a limited inspection is provided for miscellaneous openings.

Mansfield, Seattle, Dayton, Duluth, Little Rock and Champaign make the backfills with city forces and therefore, do not provide a corps of inspectors for this work.

Temporary Paving

An analysis shows that temporary paving is regularly used in 12 of the cities covered by this questionnaire, which in general consists of blocks laid on the new fill. In 15 cities the trench is left open, until permanently repaved, which in most cases involves a considerable lapse of time.

In Seattle, Detroit, Mansfield and Boston an effort is made to repave at once, which in the case of two-course pavements consists of replacing the concrete base as soon as the backfill is completed. The freshly laid base is usually protected with planks or other material until properly seasoned, after which the permanent top is replaced. Seattle reports that their one-course concrete pavements are replaced at once, allowed to season a reasonable length of time, during which the opening is barricaded and then opened to traffic. The information provided on Little Rock and Champaign is not sufficient for proper classification in this connection.

Specific mention is made in the questionnaire from 9 of the above cities, placing the responsibility for the entire operation (and it is assumed to include public liability in this connection) on the permit holder. This may be the case in other cities covered by the questionnaire but specific mention is not made.

Strengthening Pavement Over Opening

The majority of the cities, 17 in all, make no attempt to strengthen the pavement laid across the area occupied by

the ditch. In 6 of the cities, however, side bearing is provided for the new pavement on the undisturbed earth but no provision is made for additional depth of pavement. In the case of the Bronx, Richmond, Birmingham and St. Paul, this additional bearing varies frob 6 to 12 ins. Both Mansfield and Detroit indicate that additional bearing should be provided but no mention is made of the amount. Four of the cities specify both extra depth of pavement and side bearing on undisturbed soil which amounts to from 1 to 2 ins. additional thickness and 12-in. bearing all around in the case of Sandusky; 4 to 6-in. additional depth and 6 to 8-in. bearing in the case of Columbus and Pittsburgh; and 8-in. additional depth with 12-in. bearing in the case of Newcastle. Philadelphia and Champaign substitute a 1:2:4 mix concrete base with 6-in. bearing for the 1:3:6 mix base now employed. Seattle indicates that a richer mix is used together with reinforcement under some conditions but does not specify in what amount. Little Rock strengthens the new pavement by the addition of bar reinforcement only. Cleveland reports that a concrete base is laid over the area occupied by the ditch in all cases, which constitutes a strengthening in the lower type of pavement but fails to provide additional strength for the higher types. Information furnished on Cincinnati is not sufficient for classification under this head.

Permanent Paving

By far the greatest number of cities permanently repave the opening with city forces, or those of an agent, 19 falling under this classification. The entire permanent repaving operation is performed by the permit holder in Newcastle, Parkersburg and St. Louis, while only the hot top is relaid by the city of Yonkers, the permit holder doing the other work.

In 8 of the cities the public utilities do their own repaving while the city repaves all other openings. This, however, is optional with the public utilities in the case of Manhattan, Bronx, Richmond, Brooklyn, Queens and Columbus, while in Indianapolis and Sandusky the public utilities perform all repaving except the hot top, which is laid by the city. Boston and Philadelphia report that this repaving is done by one of three agencies, the contractor who holds the pavement guarantee, the city or the public utilities involved.

Recommendation

I would call special attention to the replies received from the city of Seattle. The machinery there set up, if properly administered, should be productive of excellent results. It will be recalled that while no charge is made for the issuance of a permit the cost of the work performed by the city plus 12 per cent is collected from the permit holder and kept in a revolving fund, which has been established by the city council, for the purpose of carrying on this work. The permit holder makes the cut, digs the trench and performs the necessary repairs to the underground structure involved. All cuts or openings made in public streets or alleys in the city of Seattle by private individuals or public or private utilities, are backfilled and closed by the street department at the permit holder's expense. The ordinance covering this operation authorizes the city to take over all backfilling and replacement of pavements. This permits the executive charged with the condition, maintenance and repair of the city streets, to exercise the closest kind of supervision over the making of the backfill and the repaving of all openings. It also permits the department doing this work to be independent of all restricting influences and to set up the machinery to handle this phase of their work in the most efficient and economical manner. It also insures that the backfill will be made in such a manner that the permanent paving can safely be restored upon the completion of the fill. That backfills can be made so as to eliminate practically all future settlement is indicated in Seattle's reply to Question 7, which states that no method other than the restoring of the same pavement with a better quality of concrete and a trifle thicker in depth is generally used. It is reasonable to suppose that with the degree of supervision which the Seattle Street Department can exercise over these repairs that additional depth and sidebearing would be provided should experience show this to be necessary.

Objective

The Chamber of Commerce Committee on Highways is undertaking this study in the hope that it will develop an administrative method by which a street department can exercise full control over the making of pavement openings without being dependent upon the legislative branch

of the government for funds with which to carry on this work.

Based on this questionnaire a study of the ordinances in 7 of the cities is being undertaken in the hope that an ordinance can be formed which will embody the good points of the outstanding cities without undue complication or arousing serious opposition. If a substantial part of this program can be realized, the committee will feel that the time and effort expensed on this survey will be amply justified.

SOME OUTSTANDING DEVELOPMENTS IN WARREN PAVEMENTS.

By George C. Warren, Chairman Executive Committee, Warren Brothers Company, 9 Cambridge St., Boston, Mass.

Backed by fifteen years' prior practical experience in handling of bituminous materials and the laying of bituminous pavements, the late Frederick John Warren 25 years ago conceived the idea and began scientific research in development of his, then novel, basic principle of street pavement surface construction of scientifically determined and carefully compounded aggregates of varying sizes of crushed stone or gravel and sand ranging from a maximum between 1 and 2-in. size down to a minimum of impalpable powder, thus producing a maximum stability and minimum voids in the aggregate to be combined after heating with high grade bituminous material. In the year 1901 the first practical road construction was accomplished by the laying of sample areas in New England—Pawtucket, R. I.; New Bedford, Mass., and Cambridge, Mass., in which cities the construction, which has developed and improved to the present Warrenite-Bitulithic, is now the standard, and large areas have been laid nearly every year since the first construction.

The steady and rapid growth of the construction is clearly shown by the following tabulation:

Year	Sq. Yds.
1901	16,400
1902	400,831
1903	915,630
1904	1,041,724
1905	1,041,327
1906	1,508,095
1907	1,924,222
1908	1,676,433
1909	2,071,987
1910	3,047,276
1911	4,189,182
1912	4,830,601
1913	5,081,068
1914	4,204,943
1915	4,495,393
1916	5,519,765
1917	5,219,173
1918	4,799,783
1919	7,467,331
1920	11,259,647
1921	7,547,628
1922	7,120,326
1923	9,833,461
1924 and under contract to Nov. 30, 1924	10,710,196
Total in 24 years....	105,922,620

This is equal to 6,018 miles of city roadway of an average width of 30 ft., or to 10,030 miles of county roadway of an average width of 18 ft.

This development includes states, provinces, counties and municipalities in every state of the United States and Province of Canada, with all the climatic and traffic variations of these countries.

On Columbia River Highway

Perhaps the greatest single accomplishment is the adoption of Warrenite-Bitulithic on the Columbia River Highway, Oregon, beginning with 72 miles extending easterly from the City of Portland in the year 1915, and extended during the

IDAHO FEDERAL AID PROJECT NO. 27—WARRENITE-BITULITHIC SURFACE ON ASPHALTIC CONCRETE BASE, BUILT IN 1924.

succeeding four years to an aggregate of 218 miles from Seaside on the Pacific Ocean to The Dalles in Central Oregon. This is the greatest continuous mileage of any road type in the world, and is one of the world's greatest scenic roads.

In addition to extremely important development improvements in the roadway wearing surface during the quarter century period, resulting from the best efforts of a large organization of practical road constructors, Warren Brothers Company is at least the prime factor in pressing and proving the economic success in connection with pavement foundations of:

1. Economic salvaging of old macadam and gravel roads as well as "worn out" pavements of other types as foundations for new pavement surfaces. This salvaging of old roads has already resulted in a saving of many millions of dollars in modern roadway construction.

2. That dense asphaltic concrete base, owing to its resiliency and ability to unite with the wearing surface, is a very superior and economic base for Warrenite-Bitulithic roadway surface.

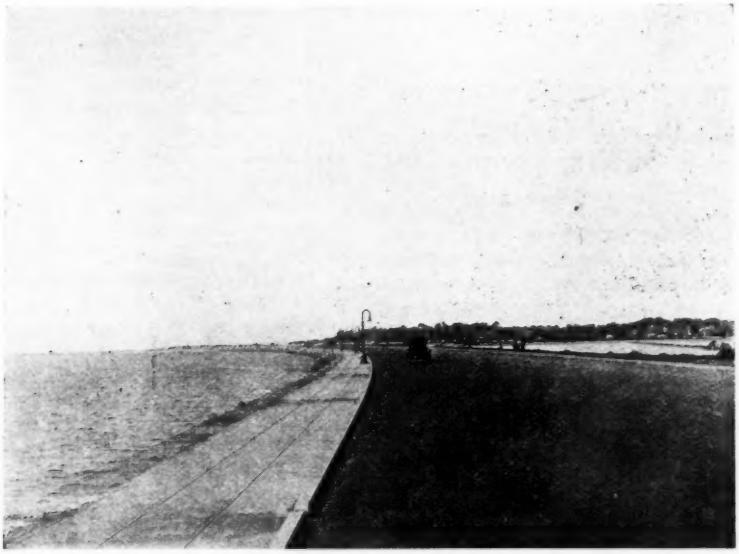
This has been proved by practical test of use under all climatic conditions, even with total depth of surface and base as low as 4 ins., a few particular references being the following:

(a) The 40 deg. below temperature of Edmonton, Alberta.

(b) The arid 120 deg., tropical climate of Phoenix, Ariz.

(c) The violent, East Coast winds and sudden temperature changes as exemplified on the Barnum Boulevard, along the Long Island Sound shore at Bridgeport, Conn.

(d) The severe climatic conditions of the Rocky Mountain States, exemplified in Idaho Falls; County, State and Federal Aid projects in the county surrounding Idaho Falls, Idaho, and Payette County, Idaho, where the summer temperature is as high as 110 deg. F. and winter with sudden changes well below zero.



WARRENITE BITULITHIC ON DENSE ASPHALTIC CONCRETE BASE, ON BARNUM BLVD., BRIDGEPORT, CONN.

(e) The hundreds of other roadways constructed during the past dozen years throughout the United States and Canada aggregating over eleven million square yards or equivalent of over 1,000 miles of roadway 18 ft. wide.

Warren Brothers Company is recognized as one of the largest and most successful road building organizations in the world, which position has been developed upon the merits of its product. Imitations come and go with a temporary splurge of something better, but the Warren policy of thorough research and conservatism speaks for itself by the Company's position in the business world.

PROGRAM OF CONVENTION AT ROAD SHOW

The complete program of the annual convention of the American Road Builders' Association to be held in Chicago, January 6, 7 and 8, 1925, has just been announced by Professor T. R. Agg, chairman of the program committee. All sessions of the convention will be held in the Elizabethan room of the Congress Hotel.

As usual, Thomas H MacDonald, chief of the United States Bureau of Public Roads, has accepted the invitation of the association to speak and will take advantage of the occasion to put before the representatives of every phase of the great highway industry some of the plans of the Federal government for highway construction. His subject will be, "Building a System of National Roads Through Federal Aid," and it will follow the opening address of President J. H. Cranford on Tuesday, January 6.

Five sessions of the convention will be held during the three days. Except on Tuesday, January 6, when there will be only one session, there will be both morning and afternoon meetings. The convention sessions will be open to all who desire to attend.

Those who attend all of the sessions of the convention will have ample opportunity to visit the show in the Coliseum as it will open on January 5 and will continue through January 9.

The complete program for the convention follows:

JANUARY 6

Morning Session, 10:30,

President Cranford presiding.

1. Opening address by President Cranford.
2. "Building a System of National Roads Through Federal Aid," Thos. H. MacDonald, Chief of Bureau of Public Roads.

Afternoon Session, 2:30

Geo. W. Tillson presiding.

3. "Impressions of English Highway Practice," Austin B. Fletcher, Consulting Engineer, Bureau of Public Roads.
4. "Are State Highway Programs on a Sound Financial Basis?" H. R. Trumbower, Economist, Bureau of Public Roads.
5. "Legal Aspects of Trunk Line Roads Through Cities and Villages," Samuel K. Markman, Chicago, Ill.
6. "Suggested Revisions in Brick Paving Practice," W. D. P. Warren, Consulting Engineer, Decatur, Ill.

JANUARY 7

Morning Session, 9:30

Paul D. Sargent presiding

7. "Relation of Traffic Surveys to Highway Programs," William H. Connell, Engineering Executive and Deputy Secretary of Highways, State of Pennsylvania.
8. "The Evolution of Highway Traffic," Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan.
9. "The Super-Highway Plans of Wayne County, Michigan," Edward N. Hines, Chairman, Board of Highway Commissioners, Wayne County, Michigan.

Afternoon Session, 2:30,

Frank Page presiding.

10. "Planning a Greater Chicago," E. S. Taylor, Manager, Chicago Plan Commission.
11. "Problems of Statewide Highway Maintenance," Frank T. Sheets, Chief Highway Engineer, Division of Highways of the State of Illinois.
12. "Utilizing the Salvage Value of Old Roadway Surfaces," A. H. Hinkle, Maintenance Engineer, Indiana Highway Department

Election of Officers.

JANUARY 8

Morning Session, 9:30,

T. J. Wasser presiding.

13. "Determination of Stability of Asphalt Paving Mixtures," Prevost Hubbard, Chemical Engineer, The Asphalt Association, New York.
14. "The Contribution of Research to Highway Progress," Frank Page, Chairman of North Carolina Highway Commission.
15. "Dust Elimination on Gravel Roads," B. C. Tiney, Maintenance Engineer, Michigan Highway Department.
16. "The Final Link in the Lincoln Highway in New Jersey," Harry D. Robbins, Division Engineer, New Jersey Highway Department.

JANUARY 8

Afternoon Session, 2:30,

A. H. Blanchard presiding.

17 "Form Setting and Its Relation to Riding Qualities of Concrete Pavements," C. N. Conner, State Construction Engineer, Raleigh, N. C.

18. "Investigations of Smoothness of Pavements," H. F. Clemmer, Engineer of Tests, Division of Highways, Springfield, Ill.

19. "The Evolution of Construction and Maintenance Equipment," O. L. Kipp, Construction Engineer, Minnesota Highway Department.

CENTRAL MIXING OF ASPHALT MASTIC BEDDING COURSE FOR BRICK PAVEMENT

By Frank R. Allen, City Engineer, Pine Bluff, Arkansas.

The expansion and growth of the industries in and about the City of Pine Bluff, Arkansas, has made necessary the improvement of many streets in the outlying districts.

The city has kept pace with this increased development by a constantly increased yardage of street paving. Many types of paving material have been used in the city, although the vitrified brick pavements predominate in yardage.

The soil underlying the streets is a blue clay which absorbs and holds a great amount of water. Not only does this prove a problem but the presence of quick-sand in many localities aggravates the condition.

The inadequacy of the present storm sewer system permits an appreciable amount of surface water to accumulate in the ground, particularly during the rainy season in the early spring. In spite of heavy concrete bases, more or less trouble is encountered each year due to the settlement of the pavement and the consequent unevenness of the wearing surface.

This year on some twenty thousand yards of repaving work, a change was made in the specification, providing for a mastic bedding course in place of the usual plain sand. The wood block paving that formerly served as a wearing surface on six or eight streets was replaced this year with vitrified brick. The brick specified were the plain wire cut type 3 ins. in depth.

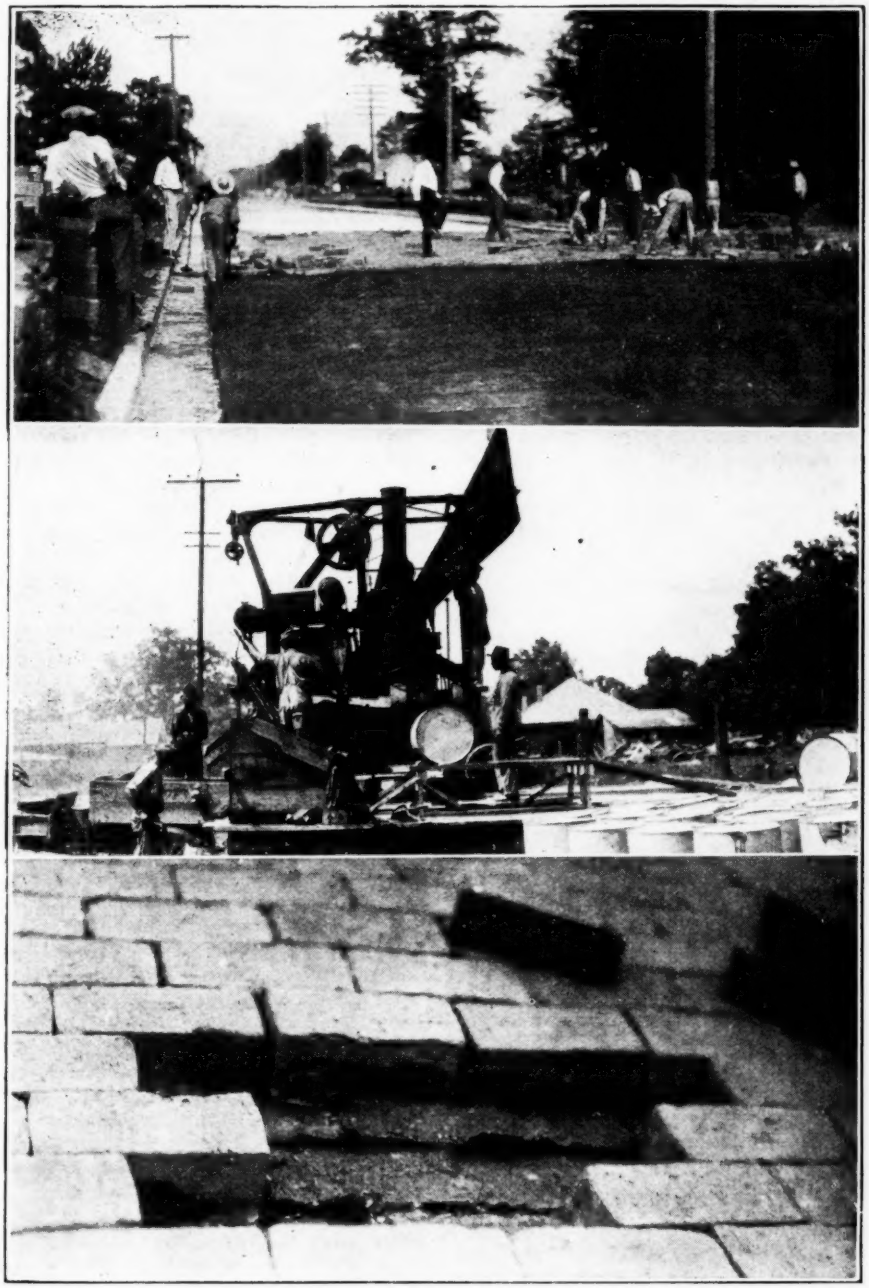
In many cases the concrete base had cracked and although these cracks were repaired, there was no assurance that the same action would not be repeated. Where the project called for a new concrete base on one of the streets not previously paved and for the replacement of sections of the old base, a mixture of 1-2½-5 gravel concrete was laid 6 ins. in depth.

To avoid the possibility of shifting of the sand bedding course, it was decided to use a mastic bedding course composed of from 5 to 7 per cent of cold tar or a suitable cut back asphalt. This bedding course was specified to be approximately ¾-in. in depth, but it was found when the old paving material was removed that this would be much exceeded in many places. The contractor had the alternative in the specifications of setting up a central mixing plant to prepare the bedding course or of mixing the sand and asphalt on the job as each day's work progressed. The central mixing plant was adopted by the contractor and a medium size concrete mixer was used to prepare the mastic bedding course. A cold patch asphalt was mixed with the sand in proportions of 4 gals. of asphalt to 600 lbs. of sand, making a percentage of approximately 5½ per cent of asphalt.

The material was mixed cold and hauled in dump trucks an average distance of one-half mile, the maximum haul being close to a mile. It was dumped on the concrete base, spread with a rake and shaped with a template in the same manner that plain sand is handled. The mastic bedding course was spread and shaped 24 hours in advance of the laying of the brick, thus giving a sufficient time for evaporation of the volatile oils before the brick were laid and the asphalt filler applied to seal the joints. It was found that when the brick were rolled, the bedding course was squeezed up between the brick approximately ½ in. The compaction was about 25 per cent under the roller, thus necessitating the bedding course being spread to a depth of 1 in. to insure the final depth after rolling being the ¾-in. specified.

Comparing the cost of the preparation and application of the mastic bedding course with that of the plain sand bed, it was found that the mastic cost 10 to 11 cts. per sq. yd. additional. This was subdivided as follows: 3c for the asphalt; 3c for mixing, and 4c to 5c for spreading.

This work was done by the Kaw Paving Company of Topeka, Kansas, George E. Williams being the superintendent in charge of the work, under the supervision and inspection of the city engineer.



USING ASPHALT MASTIC BEDDING COURSE FOR VITRIFIED BRICK PAVEMENT AT PINE BLUFF, ARKANSAS

Top: Reshaped Cushion Following Cloudburst. Center: Both Asphaltic Cushion and Concrete Mixed in This Plant. Bottom: Showing How Mastic Bedding Course Squeezed Up Between the Bricks.

THE PRESENT DAY DESIGN OF SHEET ASPHALT MIXTURES

By Gene Abson, Chicago Paving Laboratory Inc., Consulting Engineer, 536 Lake Shore Drive, Chicago, Ill.

To the pioneers in the field of asphalt paving mixture design, notably Clifford Richardson and his co-workers, belongs the largest portion of the credit for one of the greatest advances in the construction of city pavements and highways in the past half century. Until that time various materials were more or less satisfactorily employed, but the greater portion of such materials used were ones found in a natural state and which merely required application to a suitable subgrade or foundation. The knowledge pertaining to the manufacture of the various constituents, or even the combination of such various ingredients as were naturally found, was, indeed, quite limited. Pavements and roads were not in great demand and consequently the industry lagged for want of initiative.

In the field of asphalt pavements we find that reference to the use of bituminous materials extends back nearly to the dawn of history, and probably more such references are available than pertain to any other paving material. But no rational methods of using such naturally found materials were developed until the advancements in man's means of locomotion demanded a cheap, satisfactory, serviceable and sufficient supply of raw materials. Very naturally, far seeing engineers and chemists took up the problem of adapting the most universally available materials, bitumen and sand, to use as pavement constituents. Sand forms a very large portion of the earth's crust, and is found in all localities in abundance, and bitumen is found either in a hardened state or in its original source, crude petroleum oil, in almost all countries. No wonder such materials attracted the eye of men trained to look for available sources of supply of raw materials with which to construct necessities for the world's growth and advancement.

In the experimental period, most of the work naturally tended towards producing artificial mixtures of sand and asphalt which would imitate such conglomerates of sand and bitumen as had been found in European deposits. Unfortunately, nature made no attempt at producing prepared mixtures of sand and asphalt which would be suitable for pavements, but merely saturated sand beds with overflows from oil pools, the oil gradually changing to asphalt by hardening through geologic ages. It was up to man, then, to improve upon the quality of artificial mixtures and to select such types of sand and asphalt which best suited his purpose. Such has been the problem, and it is but natural that as methods of locomotion and volume of traffic changed, corresponding changes had to be made in the pavement mixtures.

In the development of such mixtures, most of the work was focused upon the formulation of successful, practical design, and only after suitable mixtures of sand, asphalt and filler were employed, was any thought given to a scientific explanation of why such-and-such was done. Consequently, theories were advanced and accepted without much consideration or attempt at proof; if a theory fitted and seemed sound, why bother much about it especially since results were produced which, at that time, were satisfactory. No criticism is intended here; mere statements of condition are given for the purpose of explanation.

The "Surface Area" Theory

In view of the limited amount of available information, the theories which were advanced were from all outward indications essentially sound, and were accepted. Only until very recent times has enough experimental work been carried on to disprove some of the original theories. By far the most outstanding difference in the present design of sheet asphalt mixtures is that which relates to the determination of percentages of asphalt, filler and sand, as well as sizes of particles of both the sand and filler which must be used. Formerly, that is, up to about five years ago, the "surface area" theory of Richardson was accepted and used as a standard. In practice it was always assumed that as the sand grains became smaller in size, and larger percentages of filler or dust were used, more bitumen would be required to cover the enormous increase in surface area. It was also known that mixtures designed upon such a basis were not entirely dense, that is, a large proportion of voids or air spaces existed. For the traffic then in vogue, these mixtures sufficed, but as traffic increased enormously in volume, weight and speed, it was found that such mixtures were more or less mobile, that is, they either "pushed" and "rolled" out of place or deep ruts were

formed under constant traffic. To overcome this, mixtures were laid with less bitumen than formerly, and the penetration of the asphalt was decreased. Such subterfuge in a measure overcame the immediate disastrous results, but decreased the ultimate life of the pavement. And, too, the surface area theory failed to explain why some sands, though showing approximately the same mesh composition, showed quite a marked variation in the amount of bitumen which was deemed necessary.

Rational Design

A rational design of sheet asphalt paving mixtures originating from actual practice and proven sound by laboratory investigation, has arisen and is steadily gaining credence among paving experts. Opposed to this newer school is a group still retaining the "surface area" theory even in face of positive evidence of its unsoundness. The newer school has based its design primarily upon "voidage," employing graded sand, sufficient filler of suitable fineness and grading to reduce the voids in the sand to a minimum, and enough bitumen to fill the remaining voids without an excess. In actual practice it has been found that the quantities required check almost exactly with laboratory results, this in itself being almost a positive indication of its soundness. On the other hand, the surface area theory could not be applied without making changes to suit each particular condition for variation in materials.

The Voidage Theory

Probably a brief description of the voidage theory and its inception will serve to make this paper more lucid. The first instance of its use occurred in Des Moines, Iowa, in 1921, when Mr. Skidmore of our organization was employed as a consultant to design a mixture for a heavy traffic street in the downtown section of that city. It was decided to use much more dust or filler in this mixture than had previously been employed, for the purpose of "toughening" the pavement. In addition to this, the sand itself contained a portion of 200-mesh particles. Based upon the then current conception of mixture designing, it would have been assumed that more than the usual amount of bitumen would be required, but had this idea prevailed, the hot mixture would have been so "lumpy" and "bally" that it never could have been laid. Therefore, in this instance, the bitumen was reduced until the mixture ceased to "ball" and assumed only a usual degree of richness. It was, indeed, surprising to note that a typical analysis showed as follows:

Bitumen	9.4%
Passing 200-mesh	27.6%
Passing 80-mesh	18.2%
Passing 40-mesh	26.3%
Passing 10-mesh	17.0%
Passing 4-mesh	1.5%

This mixture contained ample bitumen for any traffic it would receive, but an astoundingly lower amount than the surface area theory would demand. Its practical application was less difficult than with richer mixtures, although in manipulating it was found that higher temperatures were required to bring this about; under heavy rollers it compacted with no difficulty whatsoever. According to all previous theory this pavement should have cracked profusely during the first cold winter. Today, after three years, the pavement is in excellent condition, free from any imperfections.

Checking Actual Practice

This instance, followed by further practical work, clearly demonstrated that the new mixtures were going to be more successful and adaptable from all standpoints and that some feature other than "surface area" was a controlling factor in regulating bitumen percentages. With this in mind, laboratory investigation was begun and the voidage determination suggested itself as one solution. Previous to this, numerous methods of determining voidage had been used, but none gave concordant results until it was found that considerable jarring and packing was necessary to reach a minimum. Steel containers of various shapes were designed and used until the one now employed, a hemisphere, was found to give the lowest voids with a given material, and, to repeat, one which checks actual practice. This reiteration of "checking actual practice" is of enormous importance because no previous method ever approached consistent or even occasional verification when removed from the laboratory to the field.

Designing Mixtures on Voidage Basis

In designing mixtures on a voidage basis, the method evolved consists in making a series of voidage tests upon the most suitable grade of sand (determined previously by voidage test) by adding filler in increments of about 5 percent until the lowest voids, without bulking, are obtained. This percentage of filler will

vary with the grading (or voidage) of the sand as well as the fineness and grading of the filler itself, but usually ranges from about 20 to 28 percent by weight of total aggregate. The voidage is expressed in volume of compacted aggregate and, knowing this and the density, it is easy to calculate the percentage of bitumen required to fill the voids. Mixtures containing such a percentage of asphalt are plentifully supplied with bitumen, ample to cover all particles as well as fill the voids. In fact, in actual practice when the bitumen is occasionally overdrawn only ½ of 1 percent, it is enough to make the mixture so rich that it fairly glistens when rolled. This is only one evidence of the practicability of controlling such mixtures within a very close range, and obviously tends towards greater uniformity of the mixture.

Scientific Mixtures

In following the new procedure and method of determination, it can be readily shown that the design of mixtures has been removed from a haphazard, rule-of-thumb guessing contest to a design in which all varying factors are reduced to a definite, mathematical basis and really is founded upon a scientific principle. On the other hand, an attempt to apply the surface area theory of designing mixtures quickly leads one into a maze of indefiniteness. For example, the normal mixture in vogue ten years ago (showing 10.5 to 11 per cent bitumen and 13 to 15 per cent of 200-mesh filler) appears to satisfy this theory until some definite change in mixture composition is made. To illustrate, assuming that it is desirable to increase the filler 5 per cent and use 20 instead of 15 per cent, it must follow from the theory that the bitumen should be increased in proportion to the increase of surface area of the additional filler, whereas in actual field experience, it has been demonstrated that the opposite holds true, namely the bitumen must be subsequently *reduced*. Moreover, the surface area theory does not give any indication as to just what thickness of surface films is necessary or desirable. The only means of controlling the mixture, the "patstain," is inconclusive and indefinite. Mixtures showing the same stain (at the same temperature) may be made up of widely varying film thicknesses. However, it is not to be assumed that all ramifications of sand gradings, etc., have been investigated. Only sufficient research work has been finished to establish the fact that present sand grading limits are satisfactory but it may be entirely possible that complete revision of sieves and sieve proportions can be instituted without material harm. It may mean that, with sufficient filler, sands heretofore thought unfit will be entirely suitable. Likewise the arbitrary penetration limits heretofore established may also be advantageously revised. In fact, superficial laboratory investigation indicates that much softer asphalts may be safely employed. Further investigation along these lines is now being carried out.

Approaching Theoretical Density

In laboratory experiments it has been found that as the voids in the sand are filled with dust, the mixture compacts more readily and that nearly theoretical density can be obtained. With previous mixtures this could never be done. Hence, in applying these mixtures, the ultimate density is obtained by rolling without depending upon subsequent traffic fully to compress the mixture. Mixtures depending upon traffic for their ultimate compression oftentimes show surface distortion.

Opponents of this new theory, i. e., those who belong to that group of individuals which hesitates to deviate from procedure handed down from the past generation, are, of course, forcefully engaged in denouncing the soundness of voidage tests. Their argument is that the films of bitumen will be too thin to furnish any adhesiveness and that the pavements will crack. One need only examine the composition of numerous mixtures laid on concrete bases which have cracked. In nearly all cases under observation, the richer mixtures have cracked. An explanation of this may be borrowed from the glue industry where it is known that thinner films lend greater adhesiveness. Cracking also occurs in mixtures on Portland cement concrete bases irrespective of the penetration of the asphalt, as it has been demonstrated that pavements can be laid with 20 penetration AC and not crack while Kentucky Rock, with a bitumen of over 300 penetration, does crack. This definitely asserts that another feature is the controlling factor in preventing a pavement from cracking. No proponent of the "surface area" theory has yet given any logical explanation of why their own more or less porous mixtures should be less susceptible to cracking than a voidless mixture. On the other hand, the newer mix-

tures eliminate the greatest fault that formerly was found in sheet asphalt pavements, namely the "shoving and rolling" and "rutting." These mixtures are so dense that only slight superficial softening is occasioned in street parking areas, a source of much trouble formerly. The denser pavements are equally as resilient as the older ones and possess all the inherent virtues of an asphalt pavement.

RESURFACING OLD ROADS AND STREETS WITH KYROCK

Any man who travels about calling on county and city officials must be impressed with the fact that there are many more roads and streets to be built than there is money to build them with. Go into almost any county courthouse in Indiana and you will find enough road petitions on file to break up the county provided they were all granted. A great many counties and townships already have reached the legal limit of their bonded indebtedness.

Nor should one get the impression that the roads and streets petitioned for are not needed. Most emphatically they are needed. Farmers, in many instances, are unable during the winter to drive their automobiles to and from their homes. Old highways and streets which carried the traffic 10 years ago have been almost destroyed by modern traffic. Obviously the road dollar must be made to go farther.

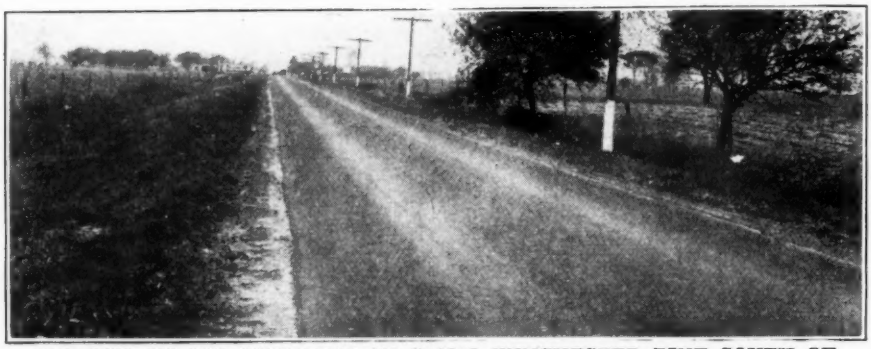
The logical answer to most of the road and street problems is maintenance, the kind of maintenance that includes everything from patching to complete resurfacing and the kind of maintenance that is carefully studied, planned and executed. So rapid has been the transition from the old horse and wagon days to modern motor traffic that many counties and cities have failed to keep pace with changing conditions. The road repair fund and the street commissioners' allowance is still looked on as a small side issue in many communities. As a matter of fact that should be considered of equal if not greater importance than the construction of new roads.

The average county or city has an investment of hundreds of thousands of dollars on old roadways. The metal is thick and has been well compacted by years of exposure and traffic. The weak spots developed long ago and have been repaired. The chief objection to these roadways is that they are rough and dusty in summer and muddy in winter. Also they require constant maintenance. Such roadways can be shaped and used as a base for a high type wearing surface and usually will give service equal to a complete new construction.

Experience has shown that surfacing these old roadways costs about half as much as new construction. Resurfacing simply means a saving of the cost of excavation and the base which would be required for the new pavement. No one can lay down a general rule that all old gravel and stone roadways can be resurfaced successfully but, undoubtedly, many old pavements are being destroyed which would make good bases for a high type surface and would give many years of good service.

Resurfacing of old roadways is not

INTERSECTION OF WASHINGTON AND ASHLAND BOULEVARDS, CHICAGO, PAVED WITH KYROCK OVER OLD MACADAM.



KYROCK ON OLD MACADAM ON CANAL-WINCHESTER PIKE SOUTH OF COLUMBUS, OHIO.

theory or experiment. Such pavements have been in service long enough to prove the advisability of such construction. In Indiana there are several such constructions that are giving excellent service.

Bedford, Ind., has an old macadam street which was surfaced with Kyrock in 1923. The old street was scarified and shaped and 2 ins. of compacted limestone spread before the Kyrock surface was laid. This street probably has had heavier traffic than any street in the city, traffic from two state highways having detoured over it during the summer of 1924. Also a part of this pavement was laid on a 10 per cent grade. The pavement has not shoved, rolled or cracked and the only maintenance has been that due to external causes, broken water pipes, etc. In Wabash County, Indiana, there is considerable of this same type of reconstruction, some of it laid as early as 1919. It is in perfect condition today.

Early in 1923, the park department of Indianapolis surfaced about 18,000 sq. yds. of old gravel pavement on the heaviest traffic section of Fall Creek boulevard. This Kyrock pavement shows no signs of distress. In fact it is ironing out smoother every day.

Chicago, Ill., some time ago rebuilt a considerable yardage of macadam streets by surfacing with Kyrock. Sections of Addison street and 113th street were notable examples of this work which has stood up under unusually heavy traffic without any maintenance. Late in 1924, Washington Boulevard, an old asphalt street, was surfaced with Kyrock. This is a through street and carries an unusual load.

The Canal-Winchester Pike (State Route 21), an old macadam roadway leading south from Columbus, Ohio, was surfaced with Kyrock by the Ohio State Highway Department in 1920. In going over the pavement a few weeks ago it was found in perfect condition. In the South there are hundreds of miles of such re-construction.

Many cities have old brick pavements which have been in service as long as 30 or 40 years. In most instances these pavements are solid but rough. Where the foundations are solid these brick streets can be surfaced with Kyrock at less than one-half the cost of a new pavement. Kyrock has been particularly successful for this class of work because of its sand aggregate. The material penetrates the interstices between the bricks

KYROCK ON OLD BRICK PAVEMENT, MAPLEWOOD AVE., AMBRIDGE, PA.

giving the surface a firm anchorage.

Several old brick pavements in Indiana have been surfaced with Kyrock. An interesting construction is that on Fourth street at Lafayette. A section of the old brick was surfaced with Kyrock early in 1922 and gave such satisfaction that the entire street was surfaced in the summer of 1924. Other work of this sort has been put in at Washington, Bedford and Seymour, Ind., and at several points in Pennsylvania.

Undoubtedly there are hundreds of miles of old roadways which would make excellent bases for a high type surface. Where two or even three miles of such pavement can be built at the cost of one mile of new construction, re-surfacing is well worth consideration.

STATE HIGHWAY OFFICIALS REPORT ON MAINTENANCE

(Editor's Note: Following is the full text of the report of the Sub-Committee on Maintenance of the American Association of State Highway Officials as presented at the 1924 convention of the Association. Mr. J. T. Donaghey, State Highway Engineer of Wisconsin, is Chairman of the Committee).

The Association at its last annual meeting, outlined the scope of work for this committee for 1925, which is as follows:

1. Study methods and costs of maintaining gravel surfaces with bituminous surface treatment.

2. Determine the best specification for asphalt and tar fillers for concrete pavement repair in various sections of the country.

3. Make a study of snow removal equipment with the end in view of developing equipment especially adapted to highway work.

4. To determine, if possible, a unit of comparative wear and carry on research work to show maintenance costs per such unit on various representative roads of different types.

Subject No. 1—Study methods and costs of maintaining gravel surfaces with bituminous surface treatment.

The necessity for protecting gravel surfaces by surface treatments where traffic averages 400 vehicles per day or more is very evident for the following reasons:

First: Conserving material.
Second: Safety and comfort.
Third: Economy.

Conserving Material

Few localities have local gravel deposits sufficient to construct the roads that will be demanded in the community.

Where traffic reaches an average 400 vehicles or more daily, the loss of material annually is not less than 300 cu. yds. per mile, which, under average conditions will cost $750 to replace. If consumed for replacement purposes on the main roads, little if any gravel will be available in the future for secondary roads, the demand for which is sure to come.

Safety and Comfort

With consequent increasing traffic, the plain gravel surfaces are a growing source of danger. This source of danger can be entirely eliminated by proper surface treatments.

The comfort and satisfaction of the user must also be considered. A constant cloud of dust is very disagreeable, unsanitary and interferes materially with the pleasure of the road user.

Costs

Where traffic reaches an average of 400 vehicles or more daily, the value of material lost annually per mile ($750) plus the surface maintenance costs will easily reach $1,000 per mile.

Bituminous Treatments

The committee recommends the use of light bitumens for surface treatment of gravel surfaces.

Where tar product is used, it should be equivalent to the product designated as T. C. I. by the Federal Government, and where an asphalt product is used, it should be the equivalent of that designated as O. C. I. by the Federal Government.

It is the opinion of the committee that better results are obtained in northern states by the use of tar products due to the necessity of breaking up the surface crusts annually. This avoids undulations which usually occur if the crust is not broken up before re-treatment. It is found that a tar crust pulverizes more easily than an asphalt crust or mat.

Methods

The committee does not recommend the surface treatment of gravel roads until they are well compacted or bonded, shaped to the proper cross section and the surface swept clean and all dust pockets removed.

Bitumens should be applied in two separate coats.

First: A priming coat of 0.2 gal. per sq. yd. is applied which should be allowed not less than 24 hours for pene-

tration. Travel need not be shut off after the application of the priming coat as the travel has a beneficial effect in ironing out the surface producing uniformity.

A second coat of 0.4 gal. per sq. yd. is then applied and covered immediately with 5 lbs. per sq. yd. of coarse sand or fine gravel. This is to prevent the bitumen from running off or forming in pools, thereby insuring penetration which is the result sought. Allow two hours or more for penetration, then apply about 10 lbs. per sq. yd. of covering, preferably pea gravel or fine stone chips; apply additional covering for a few days where needed to prevent picking up or to stop bleeding.

About 24 hours after the second application of covering, the surface should be gone over with a light planer which will move the surplus covering material to the low places and insure an even riding surface.

Maintenance Proper

The surface must be watched very carefully for the first month after treatment, and all holes, no matter how small, immediately patched.

The patching material consists of 17 gals. of the same quality of bitumen used in the surface treatment, thoroughly mixed with 1 cu. yd. of Torpedo sand.

The holes are swept clean and filled with patching material just flush with the surface. Traffic will iron the patch out quickly, and care must be taken in order that the patch will not be higher than the adjoining surface.

The patching material should be mixed well in advance, at least 3 weeks, or longer is better. Excellent results have been obtained in northern climates where patching material was laid in uncovered piles by the roadside over winter.

Two men with a light truck can easily maintain 25 miles of this type of surface.

Do not apply bituminous treatment to a gravel surface unless follow up maintenance is insured.

Retreatments

In those states where deep frosts and snow prevails for some 2 to 4 months annually, the effects of snow and frost are sure to warrant retreatment annually. As a rule, before retreatment the surface must be scarified lightly or the crust broken up by the use of a heavy blade grader. The crust is pulverized by moving it back and forth across the surface by a blade grader. Traffic assists materially in pulverizing.

This work must be done as early in the season as possible, while the temperature is around 60 deg. and the gravel base contains moisture. After pulverizing the crust, the surface is again shaped to the proper cross-section. Sufficient time should elapse to allow traffic to compact the surface. The surface is then swept and the treatment applied just as described above. The first retreatment requires but about 0.4 gal. per sq. yd. and subsequent retreatments about 0.2 to 0.3 gal. per sq. yd. annually.

Costs

The total cost of the first year's treatment as above described, including all maintenance costs, is from $900 to $1,200 per mile for a surface 22 ft. in width. This is based on bitumen at 11c per gal., delivered and 2½c per gal. for application, covering material at $3 per cu. yd. applied and the cost of preparing the surface at $75 to $100 per mile.

Asphalt

Where asphalts are used, the general methods for preparation and application are the same as described. However, in warm climates it is not advisable or necessary to break up the surface crusts annually, and in many cases asphalt surface treatments serve two or more years before retreatment is necessary.

The committee recognizes that there is a large field for investigation in bituminous surface treatments and recommends that the subject be further investigated and reported on by the Committee on Maintenance at the 1925 annual meeting.

Subject No. 2—Determine the best specification for asphalt and tar fillers for concrete pavement repair in various sections of the country.

The committee can only report progress on this subject and recommend its further consideration in conjunction with the National Research Council, with instructions to report on the same at the 1925 annual meeting.

Subject No. 3—Make study of snow removal equipment with the end in view of developing equipment especially adapted to highway work.

Snow Removal

The demand for snow removal on rural highways is constantly growing but must be governed by the volume of traffic which can normally be expected to use the highway during the winter season, and the cost of keeping the roads open to traffic.

The actual snow removal can be

avoided in many cases especially in those sections subject to drifting winds where a 4-in. fall of snow may cause hard packed drifts 10 ft. or more in depth, by first: General location avoiding high passes and keeping the route on good exposures. Furthermore, by avoiding the lee side of slopes in wind swept districts. This can be still further aided by details of location in which the grade line and through fill sections should be at least 18 ins. above the normal level of the surrounding country. Shallow through cuts should be excavated to a wide roadbed section. In many cases it will be advantageous to remove the material entirely to the right of way limits, moving the excavation to fills on either side of the cut.

However, even when these good principles of location are used, it will be found impossible to avoid all conditions where snow drifts will materialize, and in these cases local protection should be resorted to, using some form of snow fence. Investigations have shown that a light type of snow fence, using picket and wire on driven iron posts can be installed and handled at a less cost than the older so-called railroad type. In those cases where the requisite width of right of way can be obtained, permanent hedges can be planted which will serve as a snow barricade and present a more sightly appearance during the summer months. In all cases where snow fences are used it will be necessary to set them far enough back from the center line so that the toe of the drift formed will be at least 10 ft. from the cut slope. Inasmuch as the snow will lay on a slope of about 6:1, the distance the snow fence is to be set will be governed by the slope of the ground adjacent to the point in question. In some cases where extreme conditions are encountered, it will be necessary to set two or more lines of snow fence.

Type of Equipment for Snow Removal

The type of equipment recommended for use in snow removal depends upon the depth of the snow encountered and other conditions which will be taken up later. For light snow, truck plows using the mold board type mounted in front of trucks is a most economical type. This equipment will remove snow up to about 15 ins. in depth. For heavier deposits up to about 24 ins. in depth, mold board plows mounted on 5-ton "caterpillar" tractors are more satisfactory. Furthermore, this type of equipment can pass over the top of a drift, taking off the material in layers.

It is generally believed that for heavier equipment for deeper snows, the "V" plow mounted in front of a 10-ton "caterpillar" tractor is the most practical. However, from present indications, a more effective type of machine is a combination "V" type plow and rotary. This equipment has proven very effective in through cuts, and in sections where drifting winds are experienced. The rotary principle removes the snow to a sufficient distance so that subsequent drifting is not increasingly accumulative. The rotary equipment is, however, a great deal more costly and its maintenance and depreciation is heavier, so that the purchase of this type of equipment would not be justified except in particular localities where extreme heavy snow and traffic conditions warrant the increased expenditure. However, we would recommend further study and investigation of this type of equipment, with special reference to its adaptibility with tractors now in use. In all cases, snow plows should be mounted in front of the tractive power.

While we would not minimize the importance of improved snow equipment, it should be kept in mind that snow removal equipment is in actual use in some cases for only a short time during the year and conversely is in storage and idle depreciating during the greater portion of that time, consequently in those cases where the snow removal can reasonably be expected to occupy but a short time during the year, the equipment on hand should be used even though under a handicap. In certain cases it is not expedient or economical to keep a mountain passage open during the winter months. Unless the snow is removed in the spring, the pass will be closed for a long period of time subsequent to the winter period, consequently it is necessary to remove this snow in order that early spring traffic may be accommodated. In cases where the snow has compacted to a depth from 10 to 20 ft., the type of equipment recommended for snow removal is a steam shovel with a specially designed bucket of light construction with a maximum length of boom and dipper stick mounted on a multipedal tread. In certain cases this work can be contracted by a lump sum bid to good advantage.

If the road is to be kept open during the winter, the work of snow removal should proceed as a continuous operation, in which case the snow is always light

and is moved easily. The ditches and culverts should be kept clean and the drainage functioning at all times.

The snow should be removed clear of the shoulder lines and on wide hill work should proceed from the ditch side. In using the heavy "V" type plows for this work, it will be found necessary to supplement the work with the smaller mold board type plows in order to kick the snow from the ditch side toward the middle of the road where it may be handled with the larger "V" type plow.

As a detail of the work, the location of the culvert should be marked in a distinctive manner. For instance, tall red poles can be set so that culverts can be found and opened during the spring thaw. It is further recommended that the edge of the roadbed in mountain section should be marked by poles, or in other distinctive manner, for the protection of the snow plow operators.

It has been found advantageous to make snow surveys to determine the cause of drifts and to formulate plans to remove these conditions. Many times it will be found that drifts were caused by the accumulation of weeds or brush adjacent to the roadway, or by board fences or board gates, and the removal of these obstructions will alleviate the condition. Furthermore, these investigations will disclose the proper places to set up snow fences. In addition to the information that the observer may gain under actual snow conditions, it is suggested that the opinion of local residents in regard to these matters, be ascertained.

During the past season snow was removed from approximately 60,000 miles of highway in the United States. The cost of the removal ranged from $2.00 to $200 per mile, depending on the depth of snow and other features. The average was $60 per mile.

In conclusion, inasmuch as snow removal on a major scale is a comparatively new procedure, and that undoubtedly great strides will be made both in types of equipment and methods of operation, it is the recommendation of this committee that this subject be still further considered at the next meeting of this organization.

Subject No. 4—To determine if possible the unit of comparative wear and carry on research work to show maintenance costs per such unit on various representative roads of different types.

The committee can only report progress on this subject and recommend that it be further investigated in connection with the National Research Council.

The committee also recommends the following scope of committee work for 1925:

1. Continue the study methods and costs of maintaining gravel surfaces with bituminous surface treatment.
2. Continue a study to determine the best specification for asphalt and tar fillers for concrete pavement repair in various sections of the country.
3. To study practical methods and design of patching concrete surfaces.
4. To continue the study of snow removal equipment.
5. To continue the study of determining if possible the unit of comparative wear in order to show maintenance costs for such unit on various representative roads of different types.

REJUVENATING OLD BRICK SEWERS RAPIDLY AND THOROUGHLY

By Frank W. Skinner, Consulting Engineer, 29 Vesey St., New York, N. Y.

(Editor's Note: This article features an entirely new pneumatic concrete gun first used in New York City.)

The threatened failure of old relief sewers in the borough of Brooklyn, New York, has been averted, and the troublesome and expensive construction of new ones has been avoided, their service has been maintained uninterruptedly and assured for the future by the simple and economical expedient of building in them new concrete sidewalls and arches that fully support the old structure and resist any external stresses that can be exerted on them.

By this method, which can be modified to suit almost any weak sewer with a small average flow and dimensions large enough to permit a few inches reduction without diminishing too much the hydraulic capacity, more than 4,600 ft. of costly brick sewer 30 ft. below street level will have been made entirely safe, satisfactory and permanently durable in about 6 months by a small force placing about 4,000 yds. of concrete by simple methods, where it will do the most good.

The 2,500 linear ft. of 10-ft. circular sewer in Greene avenue has a 3-ring brick arch that had in some places, after long service, become cracked, spalled or settled so that there was a possibility of a

serious collapse which has been eliminated, and a long new lease of life and usefulness secured by the repair work commenced last July that will probably be completed about the end of this year at a cost far below that of replacing the sewer on the same or another alignment, besides avoiding any street opening or construction.

Small gangs worked 8-hour shifts daily in both directions from the bottom of a manhole used as a construction shaft in Greene avenue. This manhole will eventually be closed and another manhole utilized nearer to the future positions of the working points. The gang first built a temporary floor under which a moderate amount of storm water can flow without interrupting construction operations. A field office, limited material storage, air compressor and derrick operated by a Lidgerwood hoisting engine are provided at the top of the shaft. A 6-man gang with pneumatic chipping hammers removed about 11 yds. of brick daily from the sidewalls providing 18-in. footings for new vertical sidewalls reaching from the invert to the spring line. After these were concreted by hand in wooden forms, ordinary wooden arch centers, 14 ft. long, were set up on them and the arch sections concreted by means of a concrete gun installed by John R. Fitzgerald, which placed from 15 to 18 yds. of concrete in 3 hours with 60 to 72 one-batch shots, effecting a large saving of time and labor over hand work and producing a dense, smooth-surface concrete that is claimed to be materially stronger than hand-placed concrete, especially at the crown where it impacts violently against the concrete already in place. Concrete is delivered from the street above through an 8-in. vertical pipe to a ½-yd. car on the service track on the wooden floor and from it is shoveled into the barrel of the concrete gun. Air at 85 lbs. pressure is turned on and an electrically driven internal pushing device started and in a few seconds the contents of the barrel are discharged through about 25 ft. of 6-in. hose to the top of the arch inside the form that is filled on both sides by gravity.

Abundance of compressed air for the gun and for the pneumatic hammers is delivered from the foot of the shaft through 1½-in. pipes which are supplied from a compressor in the street with a capacity of 300 cu. ft. per minute of free air. A total force of about 50 men is employed and the several gangs maintain a progress in the different kinds of work corresponding to a total advance, in both ends of the sewer, of 28 ft. of finished lining per 8-hour shift.

About 2,150 ft. of the 54x69-in. egg-shape sewer in Lewis avenue, was in similar condition to the Greene avenue sewer and is now being lined throughout, arch, invert and sides, with concrete from 6 to 9 ins. in thickness which is mixed in 2 surface machines, delivered through 2 vertical 8-in. pipes to cars running on a

RELINING THE LEWIS AVE. BRICK SEWER IN BROOKLYN WITH CONCRETE BY PNEUMATIC PROCESS.

track just above the invert, and placed by hand in 15-ft. sections of steel forms, one of which at each end of the sewer is concreted daily, a force of about 20 men advancing about 28 ft. per shift and using about 14 yds. of concrete.

The steel forms, designed by the contractor, are made in two pieces, an arch and an invert section, bolted together through the flanges of longitudinal channels stiffening their edges and adjustable by horizontal transverse screw rods that are set up to strip them from the concrete surface.

All the concrete for both sewers is made 1:2:4 with 6 bags of Portland cement per yard. Aggregate and cement are delivered daily by motor trucks and only a few hours' supply is maintained in the street near the mixing machines. The total quantities required for both sewers include about 4,000 yds. ¾-in gravel, 2,000 yds. sand and 25,000 bags

Atlas Portland cement, 30,000 ft. bm. of lumber and about 48 tons of deformed reinforcement bars. The work has been prosecuted steadily except a few days when the men were driven out by storms producing a large flow of water through the sewers without damaging the work or equipment. It was designed under the direction of A. J. Griffin, chief engineer, and I. H. Kirby, division engineer, of the bureau of sewers. Booth & Flinn, New York, W. E. Chamberlain, chief engineer, is the contractor. Morgan Bateman is the superintendent in charge, and Thomas Donahue and James Howard are inspectors for the city.

HIGHWAY RESEARCH BOARD REPORT ON HIGHWAY TRAFFIC ANALYSIS

(Editor's Note: Following is the full text of the report of Committee No. 4, on Highway Traffic Analysis of the Highway Research Board, as recently presented. Mr. G. E. Hamlin, Superintendent of Repairs of the Connecticut Highway Commission, Hartford, Conn, is Chairman of the Committee. The other members of the Committee are: A. H. Blanchard, A. N. Johnson, John H. Mullen, N. W. Daugherty and J. G. McKay).

Your Committee No. 4 on Highway Traffic Analysis submits the following reports on the assigned subjects:

Report on a Study of the Increase in Motor Vehicle Registration to Determine Factors for Forecasting Future Traffic and a Saturation Point.

Future Traffic

During the past year the Committee has thoroughly investigated the practicability of determining a factor for forecasting future traffic based on an increase in motor vehicle registration.

It has been found that the future traffic on any given highway is a function of many variables, such as: (1) The relation of the given highway to other highways of national, state, county, township or municipal systems; (2) such highway factors as width, grade, type of wearing surface, character of maintenance, including snow removal, lack of safety accessories, etc.; (3) motor vehicle legislation relative to speeds and licenses and physical characteristics of motor vehicles; (4) state and urban traffic regulations; (5) density of traffic; (6) character of vehicles using a given highway; (7) population and wealth per capita; (8) present and future commercial transport developments; (9) character of terminii of certain highways; (10) competing and co-operating carriers, such as steam and electric railroads, water transportation facilities and motor bus lines; (11) increase in the utilization of motor vehicles as indicated by registration statistics; and (12) several miscellaneous factors. It is self-evident, therefore, that the future traffic on a given highway is dependent upon many local conditions and that it is impracticable to determine a factor, based on motor vehicle registration, for forecasting future traffic which would be anything but misleading from the standpoint of general application.

The Committee recommends that the determination of the future traffic on a given highway should only be based upon a comprehensive highway transport survey which should include all investigations in the field and office which are necessary to ascertain the probable amount and character of the future traffic which will use a given highway during the lives of its several component parts.

Saturation Point

The Committee believes that the first point of attack in connection with the determination of a factor for forecasting a saturation point in the utilization of motor vehicles is to adopt some definition for saturation. The Century Dictionary states that "saturation is the act of saturating or supplying to fullness, or the state of being saturated." Further, it states that "saturate (in chemistry) is to impregnate or unite with till no more can be received;" and that "saturate (in physics) is to magnetize to saturation, or so that the intensity of its magnetization is the greatest which it can retain."

Granted normal increases in population in the United States and in each of the states of the Union, the Committee is firmly of the opinion that there will be no saturation point in the utilization of motor vehicles within our life time, except in congested urban districts. Statistics show that the population has increased in the United States per decade during the past 50 years from 15 per cent to 30 per cent. It is therefore logical to assume that even in California, where there is one motor vehicle to every three persons, the saturation point, as defined by the Century Dictionary, has not been

reached nor is it liable to be reached in growth in the near future, as indicated by the growth in population from 1,486,000 in 1900 to 2,378,000 in 1910 to 3,427,000 in 1920. Although these remarks refer particularly to automobiles, in the field of utilization of motor trucks we are at the present time much further from the time when it is justifiable to discuss a saturation point with reference to this class of vehicles.

Statistics pertaining to the registration of motor vehicles and the number of people per car in a given community give very little valuable information at the present time pertaining to determination of a saturation point. For example, the following statistics are quoted covering states which varied to a marked extent in the persons per car in 1920.

Year	Total Registration	No. of People per Motor Vehicle
	IOWA	
1920	437,000	5.5
1921	461,000	5.2
1922	500,000	4.8
1923	571,000	4.0
	TEXAS	
1920	428,000	10.9
1921	468,000	9.9
1922	526,000	8.9
1923	688,000	7.0
	NEW YORK	
1920	670,000	15.5
1921	779,000	13.3
1922	1,002,000	10.4
1923	1,204,000	9.0
	ALABAMA	
1920	75,000	31.4
1921	82,000	28.5
1922	90,000	26.1
1923	126,000	19.0

It is self-evident that the saturation point in the utilization of motor vehicles in any given community will also depend on such factors as: (1) Wealth and income per capita; (2) status of highway improvement; (3) parking restrictions in municipalities; (4) compulsory liability insurance; (5) financial policies pertaining to highway improvement; (6) tendency to use higher priced cars and not to trade in motor vehicles, as frequently as has been the practice, due to the high annual cost of turning in cars frequently on account of lower turnover in rate caused by the glut on the market of used cars, due to loss in time in breaking in a new car, and due to less repairs on higher priced than on lower priced cars; and (7) development of bus lines and school buses, the former particularly affecting the use of cars by salesmen, and both affecting residents of rural communities who do not consider that they can own both a family car and a motor truck, the latter being considered a necessity in the operation of many farms.

The Committee, therefore, has come to the conclusion that it is useless to endeavor at the present time to consider further the determination of a factor for forecasting the saturation point in the utilization of motor vehicles in any community except in congested urban districts.

A Study of the Width of Highway Required to be Constructed for the Estimated Life of the Type of Construction.

Width of Highway

A study of the width of highway required to be constructed for the estimated life of the type of construction resolves itself into a study of the probable development of future traffic. For the past 10 or 15 years we have been in a period of transition to motor transportation and up to just recently there was no basis for prediction as to the development of this new form of transportation nor until the last few years was there any attempt at uniform regulation of traffic or of the type and size of vehicles. This in part accounts for the inadequacy of many of the older highways. However, under present conditions with regulation of the type and size of vehicles and the growing control of traffic on the highways, we are enabled to arrive at reasonable assumptions from which to guide road design so as to avoid waste in construction. This, of course, involves an analysis of the probable source, destination, and character of the traffic based upon a liberal survey of the territory to be served or which is tributary to the road. There are, in general, the following features to consider:

Features to Consider

First, is the road primarily for local or for interurban service? If local, what is the tributary area, the density of population, and character of future tonnage, and is there a probaility of a road becoming a recreational route? In other words, will construction of a local road, by reason of the character of the country, develop market gardening, dairy business, etc., or bring about pleasure or resort traffic in addition to the normal and, if so, to what extent? Ordinarily a road which may be classed as local, i. e., 500 to 1,000 vehicles per day, requires a minimum width of 18 ft. of roadway to provide for two lines of traffic, of which only a small per cent consists of buses or

trucks, and with shoulder width or a total width between edges of gutters or ditches of not less than 30 ft. to allow parking of vehicles outside of the travel way. The drainage structures on such a road should be preferably not less than 30 ft. clear width, but never less than the combined width of travel way and shoulders.

If the road is in the nature of a through or interurban route or may so develop, the case is more difficult and especially if the road is on the line of inter-state or long distance travel, for the development of this transportation cannot be so easily predicted. Generally speaking, however, the same treatment of the subject applies as in the case of local roads, that is, an analysis must be made of the source, destination and probable character and volume of the passenger, express or freight business to be served.

Between the local road and the heavily traveled road there may exist a class relative to which there is insufficient evidence at hand to determine the operating safety of the three-lane road. The Committee considers that the desirability or lack of desirability of such a road should be the subject for further investigation before a recommendation can be made concerning the three-way road.

Between congested manufacturing or industrial areas which will introduce a large volume of express and freight business that must move with considerably less speed than the passenger traffic, the roadway should be designed so as to provide for at least four distinct lanes for traffic.

It is imperative that highway authorities study the question of adequate right of way to provide for future highway needs and that immediate steps be taken toward the establishment of present property lines and the acquisition of needed right of way future traffic developments. The Committee considers the subject of adequate right of way widths as a major topic in its program for the coming year.

A Study of the Economic Value of Elimination of Bottle-Neck Points in Relation to Their Restrictions of Maximum Road Capacity.

Elimination of "Bottle Necks"

The increase in the number of motor vehicles using a heavily traveled highway has caused a condition where, by numbers alone, the road capacity has been reduced. Observations taken over such a highway during a particularly congested period have made it apparent that the reduction of speed due to any physical cause materially reduces the road capacity. Two specific instances are cited as possibly typical of this conclusion.

In Connecticut

In Connecticut, on the Hartford-New Haven road, at what is known locally as the Yalesville Underpass, the main road passes through an arch culvert entering by a right angle turn with a sight line restricted to 25 ft. Traffic flow tests at this point during congested hours showed that the average speed was between 10 and 15 miles per hour with considerable element of danger. To eliminate this condition, a new concrete highway was built on a long curve approaching the underpass, with a clear vision of not less than 350 ft. Tests made during one of the football games at New Haven showed the passage of vehicles through the underpass at an average speed of 25 to 30 miles per hour with safety and convenience. Under previous conditions slowing of the line of vehicles was observed for a distance of more than a mile to the north of the underpass. After the construction of the new roadway no slowing of the vehicle speed was noticed on either side of the underpass, the average speed being maintained through this section practically as well as on the tangents to the north and south.

Another case in point occurred at the entrance to Bridgeport, where the raising of the drawbridge for a period of four minutes resulted in a line of waiting cars four and five abreast for a distance of over one-half mile.

Many studies are being made at the present time to counteract these conditions and wider roads and secondary roads are being planned where, in many cases, economic value cannot be shown. It being considered that the cost of such a road may approximate $100,000 per mile, enough care is not being taken to determine whether, by the expenditure of small sums locally, the free movement of the vehicle over any particular section of highway may not be maintained at a minimum cost.

If, through a point of local congestion, the average speed per hour is restricted from 30 miles to 15 miles, the number of vehicles actually using this section of highway will be reduced materially, this point of congestion or retardation being responsible for the slowing and irregu-

larity of traffic to a large extent through the entire length of the highway.

With this in mind, the economic study of each road should include a survey which will develop points of congestion or retardation. A study of each of these points will, in turn, develop the method to be employed to relieve the congestion at a minimum expense. The relief of such determining points will include the flattening of all curves of short radius, together with the widening of the travel path, the removal of any obstructions to a clear vision on the inside of a curve, the widening of rock and earth cuts to the maximum width of highway elsewhere found, the compounding of vertical curves to increase the sight line at hill crests, the banking of all curves to conform with the average speed of traffic, and the proper marking and signing of all highways so that the travel may be furnished with an accurate fore-knowledge of road conditions to be encountered.

In addition, a minimum speed limit on highways with four or more traffic lanes should be determined and enforced by law. As stated in last year's report, it is probable that to the slow moving vehicle can be charged the larger proportion of accident cases upon highways outside of urban districts.

On a highway properly constructed, maintained and controlled, with suitable signs, the maximum speed can be raised to a point where the road capacity will be increased to a large extent with safety and convenience. Vehicular speed materially affects road capacity. It therefore follows that to any one point of congestion or slow-moving vehicle may be charged the restriction of free, quick, and safe passage over a highway.

The Committee recommends that the problems of grade crossings and singlt lane bridges on two-way highways are subjects requiring immediate investigation and report.

Selection of Type Based on Traffic Requirements

Your Committee wishes to stress the need of a careful economic study of the relation of highway design to traffic needs during the estimated life of any particular type of wearing course and the annual costs of different types of wearing courses, before making highway expenditures. The view is too prevalent that the high class, expensive type of pavement is the solution of all road problems. It is not necessary to trace the origin of this view, but rather combat it with known facts. It is poor engineering to underdesign, but poorer engineering to overdesign. Available highway funds are so limited that many miles of wearing courses capable of carrying traffic 365 days in the year are more needed than a few miles of high class pavement overdesigned for the particular traffic to be carried during the life of the type of pavement used. There is a place for the high type pavement, and as traffic increases on a particular highway the investment in such pavement will be justified.

Highway Transport Surveys

I—Purposes of a Transportation Survey.

1. Highway administration and engineering data.

(1) To determine daily, seasonal and yearly traffic density and distribution on state highway systems.

(2) To estimate future traffic on state highway systems.

(3) To determine the relation of traffic density to the factors responsible for the growth of traffic, such as motor vehicle registration, production and population.

(4) To classify highways as industrial, high, medium or low type traffic routes and determine design requirements based on (1) passenger car and motor truck density and (2) motor truck capacities, gross loads and prevailing wheel loads.

(5) To determine highway width in proportion to traffic.

(6) To estimate the extent to which the improvement of old or the opening of new traffic routes is economically justified.

(7) To correlate traffic loads and density on the highways with highway construction and maintenance costs.

(8) To determine the type and volume of traffic on the highway as an index to the allocation of highway construction and maintenance funds.

(9) To determine the amount and frequency of motor truck overloading.

(10) To compare the cost of various types of highway improvements such as relocations, grade reductions, elimination of grade crossings (both rail and highway), traffic "bottle necks," with the estimated saving in transportation costs resulting from such improvements.

(11) To compare the earning value of the state highway system (based on pas-

senger miles and freight ton miles) with the present worth of the highway system using replacement value minus depreciation as the basis of computing present worth.

2. Highway economic data.

(1) To obtain highway transportation information concerning the volume of tonnage shipped by motor truck and the relation of highway transportation to other types of transportation.

(2) To determine the mileage zones of motor truck haulage.

(3) To determine the situs of ownership of passenger cars and motor trucks operating over the highway systems.

(4) To estimate the value of motor truck net tonnage hauled over the highway systems.

(5) To determine the type of origin and destination as well as the origin and destination of net tonnage of commodities transported by motor truck over the highway systems.

(6) To estimate passenger car business and non-business usage of highways.

(7) To determine the proportion of farm traffic on the highways.

II—Costs of a Transportation Survey.

The cost of a survey which will furnish data adequately to answer the purposes outlined above will vary with the size of the state, the mileage of highways, relative density of traffic, and the thoroughness with which the highway system is surveyed. The cost will be divided approximately as follows:

1. Administration and analysis of data, 15 to 25 per cent.
2. Field Expenses, 75 to 85 per cent.
   (a) Equipment, 15 per cent.
   (a) Salaries of field personnel, 60 to 70 per cent.

III—Typical Organization of Highway Transportation Survey.

1. Highway Transport Engineer.

Duties: Responsible for planning and direction of the survey and supplementary data.

(1) Assistant Transport Engineer.

(2) Office Personnel.

Duties: Responsible for direction of office force in analysis of survey data and obtaining additional data to supplement the traffic survey records.

2. Field Manager.

Duties: Responsibility for field work, general supervision and inspection.

(1) Division Supervisors.

Duties: Responsibility under Field Manager for successful operation of one section of area surveyed. In a state the size of Pennsylvania or Ohio, about one-fourth to one-third of state.

Close and regular inspection and supervision of parties operating in Division. Detailed inspection of all data obtained in Division. Each Division Supervisor has supervision of from three to six operating parties.

(2) Operating Parties.

Duties: To record prescribed data at specified locations. Parties vary in size from 2 to 8 men and are in charge of a party chief who is responsible for the efficient operation of his party. Operating parties are of two types:

(a) Recording parties, complete density records on all types of vehicles, detailed information on passenger cars, and detailed information except weights on all trucks.

(b) Weight parties, all data recorded by recording parties and weight data on all trucks.

Weight parties operate a sufficient number of stations to obtain samples of truck weights in sufficient numbers to determine accurate average weights, and accurate distribution of weights on various roads. Under average traffic conditions from 30 to 50 per cent of all stations should be weight stations.

(3) Operation.

Each station is operated for a ten-hour period one day each month. The schedule of operation is so arranged that operations cover each day of the week. Hours of operation are so arranged that adequate records are obtained for all hours of the day.

IV—Equipment Required.

Motor vehicles.

Automobiles for Field Manager, Assistant Field Manager, and Division Supervisors.

Light trucks (speed wagons) for weight parties.

Light cars for recording parties.

Portable scales for weight parties.

"Drive On" Loadometers or Berry scales.

Tally clickers for recording density.

Miscellaneous small equipment, traffic signs, etc.

V—Data Recorded.

1. Weighing Stations.

At these stations the following data will be recorded.

(a) Trucks.

Density per hour, State of license, situs of ownership, make, capacity, body width,

body type, origin and destination, type of origin and destination, commodity, value of load, type of trucking (commercial trucking company or owner operator), gross weight, front and rear axle weights, empty weight, tire type, tire size, tire depth, and tire impression on pavement.

(b) Passenger Cars.

Density per hour.

(c) Passenger Buses.

Density per hour, State of license, passenger capacity, number of passengers, name of operating company, origin and destination, mileage, trip time and tire types.

(d) Horse Drawn Vehicles.

Density per hour, origin and destination, type of origin and destination, time, commodity.

2. Recording Stations:

(a) At these stations all data is recorded similar to weight stations except truck weights and tire information.

3. Passenger car data will be obtained by sampling passenger car traffic at all stations. This data will include:

State of license, make, type of body, number of passengers, business and non-business usage, long distance touring, situs of ownership, origin, destination.

VI—Data Forms.

1. Truck Weight Sheet.
2. Truck Recording Sheet.
3. Passenger Car Data Sheet.
4. Density—Passenger Cars.
5. Density—Buses and Horse Drawn Vehicles.
6. Empty Weight Card.

It is the recommendation of this Committee that each state conduct a highway transportation survey for the purpose of obtaining traffic data for use as an aid in determining the construction and maintenance program and planning of the future highway program of the state. The minimum recommended for any state is accurate traffic density records at selected key traffic stations taken regularly each year or two years as an index of traffic over the highway system.

The Use of Highway Transport Survey Data in the Classification and Design of Highways.

There is no better index of the type of motor truck traffic over highway routes than the relative distribution of motor trucks in the light, medium, and heavy capacity groupings. The capacity of a motor truck regulates, to a large extent, the net tonnage and, consequently, the gross tonnage transported by that truck. A predominating percentage of light or heavy truck capacities on a highway route will regulate in the same way the tonnage transported over that route by trucks.

In different areas, however, the average tonnage per truck is modified by the predominating types of commodities and also by the practices in truck loading. Although it is possible to determine the type of motor trucking over highway routes on the basis of truck capacities, it is also necessary to include an analysis of motor truck gross loads and give special consideration to extremely heavy gross and wheel loads.

An analysis of motor truck capacities and gross loads, supplemented by wheel load evidence, determines the type of truck traffic on highway routes and, supplemented by truck and passenger car density, indicates the volume of traffic. By comparing the type and volume of traffic and including an analysis of future traffic, the relative importance of highway routes can be determined and the routes classified as industrial, high, medium, or low-type traffic highways. The type of highway construction, design and width necessary adequately to serve the traffic can then be reasonably determined.

Of the Pennsylvania highways analyzed, Route 142, the Philadelphia-Ardmore section of the Lincoln Highway, has the heaviest truck traffic. On this Route 22.2 per cent of the total trucks are of 5-ton capacity or larger and 14.8 per cent of the total gross loads are over 18,000 lbs. On Route 180, the Chester-Philadelphia highway, 20.4 per cent of the total trucks are of 5 to 7½-ton capacity, and 10.9 per cent of the total gross loads are over 18,000 lbs. These routes, having a very high percentage not only of large trucks but also of heavy gross loads, can be classified as industrial highways.

Examples of high-type traffic routes in Pennsylvania are: Route 43, Gettysburg-Chambersburg section of the Lincoln Highway; Route 128, the Lancaster-York section of the Lincoln Highway; and Route 156, the Doylestown-Phillipsburg. Highway. The 5 to 7½-ton trucks are 10.3 per cent of the total traffic on Route 43, 10.7 per cent on Route 128, and 11.3 per cent on Route 156. The gross loads over 18,000 lbs. are 10.9 per cent of the total loads on Route 43, 7.9 per cent on Route 128, and 9.5 per cent on Route 156.

The heavy traffic on these routes is a sharp contrast to traffic on Route 84, the Erie-Meadville Highway. Of the total trucks on this route there are none over 4-ton capacity and only 14.8 per cent are over 1½-ton. Of the total gross loads only 1.9 per cent are over 18,000 lbs., and there are none over 24,000. This route can be classified as a medium-type highway.

The wide variation between heavy truck traffic on one highway and extremely light traffic on another shows clearly the necessity for different types of highway construction and design to meet traffic needs. It indicates the necessity of the classification of highways on the basis of motor truck capacities and gross loads and the subsequent construction and design of highways on the basis of their classification.

Similar comparisons and classifications can be made for Connecticut and Cook County highways. Of the total trucks on State Route 42, Indianapolis Avenue, in Cook County, 4.5 per cent are 6 to 7½-ton capacities and 19.0 per cent are 5-ton capacities. Extremely heavy trucking on this route, as compared with other Cook County highways, is further exemplified by the fact that 12.9 per cent of the total gross loads are over 24,000 lbs., and 20.5 per cent are over 18,000 lbs.

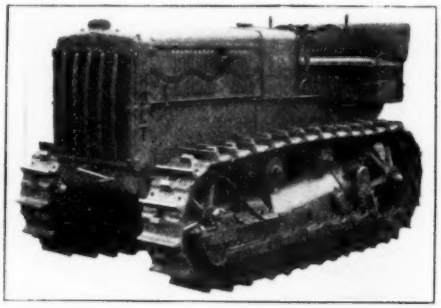
In comparison with traffic on Indianapolis Avenue, the traffic on Roosevelt Road (Cook County) is relatively light. Of the total trucks only 1.0 per cent are over 5½-ton and 5.8 per cent over 4-ton. Of the total gross loads none are over 24,000 lbs. and only 5.3 per cent over 18,000 lbs. Here, again, is shown the necessity of variation in highway construction and design on the basis of motor truck capacities and gross loads.

The distribution of motor trucks by capacity and gross weight groups on Connecticut highways is fairly uniform, the New York-New Haven section of the Boston Post Road having the highest percentage of large trucks (5-ton and over) and also the highest percentage of gross loads over 24,000 lbs.

A comparison of Pennsylvania, Cook County, and Connecticut highways shows the effect of variation in the predominating types of commodities and practices of motor truck loading. It indicates that main, through highways and sections of highways near or between large centers of population carry the heaviest traffic: sections of the Lincoln Highway in Pennsylvania, Indianapolis Avenue in Cook County, and the Boston Post Road in Connecticut. It illustrates the classification and, finally, the economic construction and design of highways on the basis of motor truck capacities and gross loads.

HOLT ANNOUNCES NEW FIVE-TON "CATERPILLAR" TRACTOR

A new 5-ton "caterpillar" tractor has recently been announced by the Holt Manufacturing Company, with factories at Peoria, Ill., and Stockton, Cal. The new model embodies many new and distinct features, tending toward greater accessibility, dependability and economy. The outstanding feature of the new design is unit construction; three units, the engine, transmission and track units, forming the complete tractor.



NEW HOLT 5-TON "CATERPILLAR" TRACTOR.

The motor is a 4-cylinder, valve-in-head type, bore 4¾ ins., stroke 6 ins., 1,000 R. P. M., gear driven fan and water pump, full force feed lubrication. Special attention has been given to compactness and complete accessibility. Large side plates provide for bearing inspection and adjustment.

The transmission is selective gear type with three speeds forward and one reverse. Forward speeds are: First 1.75, second 3.00, third 4.25 M. P. H., reverse 2.00. In each speed, power is applied to the sprocket with but three gear contacts. All shafts are mounted on heavy duty ball and roller bearings. Steering clutches provide independent, yet positive drive to each track; no differential is employed.

The entire weight of the tractor is carried on the roller frame through a 3-point spring mounted suspension. The truck frame incorporates marked simplicity in

design, yet permits operation of each side to accommodate itself to the inequality of ground surface A new and unique feature is the drive link and spring construction, which permits the centers of the drive sprocket and track idler to approach each other so that the drive sprocket can slip over the space blocks, should an obstruction gain access to the track unit. The track shoes and rails are cast integral of high carbon steel, specially heat treated. The track shoes are 12 ins. wide.

The new model has been designed to meet the exacting demands in the medium power field. While nominally rated at 25 drawbar horsepower it has a substantial reserve for all conditions. Its size is admirably suited to township, municipal and special road districts, having ample power for average road grading, with flexibility, speed and economy for maintenance and patrol operations.

THE MOTORIST AND GRADE CROSSING PROTECTION

By Judge Walter Pritchard, Indianapolis, Indiana

(Editor's Note: The following address by Judge Pritchard, representing the Hoosier Motor Club, was delivered at Indiana's First Grade Crossing Safety Conference held in Indianapolis under the auspices of the Indiana Public Service Commission, in October, 1924).

We have so many penal laws and ordinances now that not many lawyers can define or give the penalties of half of them. Yet everyone else is conclusively presumed to know them, and all are constantly urged to respect them, whether they know what they are or not.

Respect for law depends chiefly upon two things: first, a genuine respect for the law because it is right; and, second, a wholesome fear of infraction because the State's agencies of enforcement are numerous and strong enough to compel obedience. Of course, if all husbands loved their wives and the wives reciprocated the sentiment—all the conferences about divorces and domestic relations would be ended. The trouble is that neither love nor respect come into the heart or mind in response to a command. The best way to bring about real respect for law is to keep our laws respectable in the opinion of well intending citizens and then provide sufficient funds for effective enforcement of ordinances.

The great multitude of our criminal laws and the resulting indifference to the enforcement of many of them, and the reluctance of juries to convict defendants when tried for the violations of others, has caused much concern to many interested in good government. It makes our criminal justice less certain than that of England, for instance, where there are fewer laws. Such students of the subject as Chief Justice Taft and Secretary Hughes have, on more than one occasion, deplored the number of our criminal laws and their variety among the several states. In view of these facts, we can render a better service to the State by urging, conservatively, that only those penal laws be passed which are essential to the public safety, than by harassing the next legislature with demands for a new volume of criminal statutes.

The toll of grade crossing accidents is appalling, and each one—as we hear of it—seems preventable. One of our well known citizens said, at a lawn fete, that he could not understand how the driver of ex-Governor Hanley's car could have driven to death directly in front of an approaching train. Within an hour after the remark he was killed in a similar accident. A short time ago, one of our most public-spirited men said to me that it was "beyond him" how so many were killed at grade crossings. He was calm and deliberate in all the relationships of life, and a careful driver; yet he himself was killed a short time afterwards while on his way to perform a public duty.

These things startle and shock. They make us grope for some preventive action. The first thought of some is more law—penal law—curbing the motorists. At present, the favorite proposal is a law compelling motorists to stop at all grade crossings. The Hoosier Motor Club opposes such a law because we do not believe it solves the problem. We do not oppose it from selfish motives although we realize that in most damage suits growing out of grade crossing accidents, the pivotal question would be—"Did the driver stop?" Some would say that he did and some would say that he did not. Most accident insurance policies, too, exempt from recovery if the insured was injured in the commission of some unlawful act. Here, again, the question first and foremost would be—"Did the driver stop?" If the driver were killed, how could his family prove that he stopped?

But these considerations would weigh but lightly if by stopping, accidents could

be prevented. The loss of time of the motorist in stopping, although there are some twenty crossings between here and Martinsville, would be trivial if the loss of life would be lessened.

If a law is passed compelling motorists to stop at all crossings, the reason for the law would be that since the motorist hasn't judgment enough to determine what stops are necessary, the legislature will determine it for him, making him stop at all crossings, as did the parent who told his bad boy that he didn't know what apples were ripe and so he mustn't eat any apples at all.

No one thinks that the driver wants to hurt anyone; least of all, that he wants to be mangled or killed. Neither will any contend that any moral turpitude is involved, as where a man fills himself with bad liquor and, with swimming head and shaking arms, drives along the highways, imperiling all whom he approaches; or another who, while speeding, crashes into and injures some fellow being and then, without stopping to offer aid or give his name, sneaks away.

Nevertheless, if such a law is passed, it must have teeth in it. Surely, as a deterrent, a mere fine would be useless where the penalty of death does not deter.

Motor clubs everywhere have been vexed and provoked with speed and traffic traps under the iniquitous fee system which still exists; their members have been fined by constables in outlying districts without being taken to court; they have been compelled to send lawyers and investigators to clear up such conditions. So they favor no laws which, in some communities, will not be enforced at all, and in others, will support a whole corps of constables and deputies; for many a motorist has paid and continued his journey, even though he believed himself innocent, rather than lose the time and money incident to appeal.

If such a law is to be passed, put days in it so that the trials shall be in courts of superior jurisdiction, where the pay of court and officers does not depend upon the convicition of the defendant.

But we assert that forced stop at every grade crossing is not only not the solution, but that such a law would be foolish and an unwarranted reflection upon the intelligence of the motoring public.

Insurance companies report that thousands were killed and injured last year by falling down stairs, regrettable occurrences which could hardly be prevented by passing penal statutes. There are speeders and those under the influence of liquor who speed over crossings, and would continue to do so in spite of a new law, just as, time after time, the drunken driver, the driver with defective brakes, the reckless speeder, the nervous booze hauler, have jammed into the gates at grade crossings and have crashed into the middle of moving trains in broad daylight. Such as these have innumerable times wrecked their cars against the abutments under track elevations. Penal statutes are already on the books for their punishment and they should be enforced with rigor and certainty.

But the average sober and discreet owner of a car, traveling along a highway, who comes to a grade crossing level with the highway and has an unobstructed view for a half-mile along the track in each direction—why should he and the rest of the traffic stop? The sudden stopping on the highway—like the Dunes Highway in the northern part of the State where most of the time there is a constant stream of traffic—would cause traffic congestion for great distances behind the crossing, which would result in collisions and other accidents produced by traffic congestion.

A little later, the driver approaches another crossing and as he draws near it he notices a condition present at hundreds of crossings in this State—a large bill-poster sign flanks the highway, cutting off his view of the track. He observes that he must ascend an incline to pass over the track. He listens and hears nothing; he twists his neck, peers around the sign and sees nothing except a sharp curve in the track around an old barn. His best chance of safety is to hurry across the crossing.

Instead, he stops at the foot of the incline because it would be unsafe to stop on the incline. When he stops, he turns off his engine. Seeing no train, he starts to cross the track. He starts his engine; his car labors up the incline in fresh gravel put there to fill in the chuck-holes; as he touches the track, he sees an engine turning the curve around the old barn. He tries to put on speed and his engine dies. He is picked off the cowcatcher a few minutes later some half-mile up the track.

This death was caused solely by the condition of the crossing and was not due to the negligence either of the train crew or the driver. We know that the momentum of heavy trains prevents quick stop-

ping; that trains travel on fixed tracks and cannot swerve or dodge; that on account of these physical causes, if for no other, the train has the right of way. But with this right goes the duty to help in making it as safe as possible for these tons of steel to dash at high speed across the highways of the State. The death rate will be decreased only by improving the crossings. No one has suggested that automobiles stop at street car tracks in the city because on city streets the track is visible to the driver.

If a law is passed compelling drivers to stop at all crossings, another law should be passed to make the first law of any value; that is, to prohibit any driver from driving alone along any highway which crosses a railroad track, and require his companion to stand upon the track and signal him. Such a law would possibly be unconstitutional as applied to drivers of private automobiles and it would be begging the issue by placing the burden on the motorist, when the crossing should be protected. To properly police the crossing, to pay officers to arrest motorists for failing to stop where stops are foolish, would be as expensive as to place watchmen at the more dangerous crossings and make them safer.

Of course, if automobiles could be kept off the crossings, there would be no accidents there. But the highways existed before the railroads, and highways now-a-days are busy thoroughfares. The ideal solution would be the elimination of the crossing, by elevation, tunnelling or separation. But the average cost of elimination is $75,000 a crossing. It is not only unreasonable but impossible to expect elimination of all crossings during this generation; but the State should require the elimination of the death traps.

The view of all crossings should be unobstructed. Highways should be straightened where crooked approaches increase the danger. Warning signals should be placed at each crossing. Sharp inclines over tracks should be graded and the roadbed be made firm.

In conclusion, I quote the words of a man who has a way of taking the common sense view of even befuddling questions and thereby simplifying them. President Calvin Coolidge, speaking on grade crossing accidents, gave this advice to the National Conference upon this subject:

"Undoubtedly much can be accomplished by surrounding highway crossings with proper safeguards, giving suitable notice of approach of trains and awakening in the mind of the traveler a full sense of personal responsibility in passing over railroad crossings."

TRUCK TIRES AND HIGHWAY WEAR

By J. C. Sproull, Engineer of Tests, The B. F. Goodrich Co., Akron, Ohio

The combination of highways and motor vehicles presents one of the most important economic and engineering problems of our day. In attempting to solve this problem we have made serious mistakes. Engineers have not possessed adequate fundamental data. "Trial and error" methods have been used and the errors have been very expensive. The problem has developed so rapidly that we have been unable to foresee conditions even a few years hence. Roads which were satisfactory 10 or 12 years ago are now wrecks. They were not intended for the traffic of today. Heavier trucks are inevitable. If they can not be supported with four wheels, then six or more wheels will be used.

Truck Tires Are Conservers

While there has been a noticeable improvement in recent years of the highways and vehicles, they do not compare as favorably as they should with the roadbeds and rolling stock of railroads. It is comforting, therefore, to know that the National Government is making a serious attempt to obtain accurate fundamental data upon which to build the sciences of highway and vehicle design. These data are especially interesting to tire manufacturers whose product lies between vehicle and highway. Truck tires are intended to be conservers. They should conserve road, vehicle, cargo and fuel.

Impact Studies

The truck tire problem is by no means simple. Improvements are constantly being made to meet the requirements of increased loads and speeds. Tire manufacturers are therefore keenly interested in the impact studies which are being conducted by the Bureau of Public Roads in cooperation with the Society of Automotive Engineers and the Rubber Association of America. Through the Rubber Association tire manufacturers have established an official representative in Washington, Mr. Reid, to cooperate with the Bureau in this work. Tires and other equipment have been furnished gratis

and will continue to be donated as needed.

Purposes of Tires

While our time is very limited, I believe there is sufficient time to consider very briefly two of the more important purposes of solid and cushion tires:

The first of these purposes is to act as a cushion between vehicle and road. In general, the greater the deflection of a tire the greater its cushioning properties. A comparatively soft tire is therefore desirable from the cushioning standpoint.

The second of these purposes is to conserve fuel. In general, the smaller the deflection of a tire the smaller its power consumption. A comparatively hard tire is therefore desirable from the power consumption standpoint. To illustrate, a solid ivory tire rolling upon a very hard, smooth road similar, for instance, to glass would consume very little power. Conversely, if all of the wheels of a freight train were equipped with comparatively soft rubber truck tires, the power consumption would be so great that a locomotive would probably be unable even to "jar" the train.

Hard Tires and Fuel Economics

In general, the harder the tire the greater the road stresses produced. This has been recognized in legislation limiting the maximum allowable unit pressure between tire and road surface. No one questions the wisdom of such legislation provided the limits are wisely chosen. It is easily seen, however, that if truck tires be made so soft as to greatly increase their power consumption, the economic waste of fuel may become very important even when compared with the cost of the roads themselves.

A Medium Hard Tire

The tire manufacturer, therefore, is compelled to choose a middle ground between the tire which is too hard and the tire which is too soft. Truck manufacturers and operators demand tires of low power consumption. State highway commissioners demand truck tires with maximum cushioning properties. It is not very difficult, therefore, for the tire manufacturers to make a mistake. The impact studies have demonstrated already their value to the tire group by establishing reliable means of comparison of the performance of various types of tires. Undoubtedly in the end these studies will have a profound influence not only upon tire design but also upon legislation intended to regulate the use of tires and to protect the roads.

Legal Aspects

The legal aspect of the transportaion problem is of deep interest to the tire group. The laws of the several states differ widely. Truck tires which are legal in one state become illegal when they cross the state line. Interstate truck traffic is becoming more and more important and uniform traffic legislation is highly desirable. Let us hope that the investigation which is being conducted by the Bureau of Public Roads will result in a development of sound principles which will serve as a basis for just and reasonably uniform legislation.

The foregoing is a digest of the discussion by Mr. Sproull of the report of the Committee on Structural Design of Highways at the annual meeting of the Highway Research Board at Washington, D. C., on December 4, 1924.

MOTOR REVENUES AND HIGHWAY NEEDS IN PENNSYLVANIA

"Two statements oddly at variance relative to highway needs of Pennsylvania appeared in some of the Pennsylvania papers yesterday," said Acting Secretary of Highways William H. Connell, on Dec. 11, 1924. "In one statement John A. McSparran of the Pennsylvania State Grange says Pennsylvania needs more all weather roads. In the other a federation of passenger car owners and operators makes the extraordinary declaration that it favors a reduction of motor license fees of about $3,000,000 per year. This is issued by this Pennsylvania motor organization in spite of the fact that recently the Department of Highways issued several statements showing that in 1924 it will spend approximately $2,000,000 more on general maintenance of the state highway system than it will receive in motor license fees for 1924.

"The average Pennsylvania motorist in eight days spends more money in the operation of his automobile than he pays in one year to the State for maintenance of the roads he uses.

"President McSparran of the State Grange rightfully recognizes the great importance of getting all the people of Pennsylvania out of the mud. But as he voices this idea the motor organization which says it has 100,000 members suggests the reduction of motor revenues, the effect of which would be to postpone getting all of Pennsylvania out of the mud.

"How this federation can issue such a statement without first going over the books and expenses of the Department of Highways to determine the maintenance needs is beyond my comprehension!

"Furthermore, isn't it a fact that every Pennsylvania motorist demands well-maintained roads on the state highway system—and more of them? Personally I have never met a single motor car owner or driver who objected to paying to keep the state roads in good condition, for his comfort and convenience.

"The cost per mile for the operation of the average passenger automobile—which includes interest on the investment, wear-and-tear, oil, gas, and so on, is about ten cents a mile. The average distance traveled daily by the motor vehicles paying registration fees in Pennsylvania is about 14 miles. Some travel more, some less, that is the average. The cost of operating some passenger cars is 30 cents a mile, but the average approximates 10 cts. So if the average daily distance is 14 miles, the daily operating cost per car is $1.40, and the average Pennsylvania registration fees are $11.25 per year, it will be seen that in eight days the Pennsylvania motorist spends more money for the operation of his car than he pays for one year's use of the state highways.

"This leads me to believe that the statement by the motor organization does not accurately represent the sentiment of the 1,300,000 Pennsylvania motorists. As a matter of fact this statement only claims to speak for 100,000.

"The Department of Highways is Pennsylvania's highway transportation agency. Its first duty is to see that the roads on the state highway system are kept in a proper condition for use of the motorists who pay license fees to travel over them with the least inconvenience and the greatest comfort.

"The whole proposition can be summed up in three questions and answers:

"Q. For what purpose are the motor license fees used by the Department of Highways? A. They are used for expenses applicable to general maintenance of the state highway system.

"Q. For whom are these roads being maintained? A. The motor traffic of Pennsylvania.

"Q. Under these circumstances who should pay the maintenance cost? A.—

"I ask fair-minded Pennsylvanians to answer the last question themselves. If the road users should not pay for the upkeep up the roads who should?"

HIGHWAY PROGRESS IN MISSOURI

To the Editor:

On November 4, Missouri voted a 50 per cent increase in motor registration fees, and a 2 ct. gasoline tax. This is in addition to the $60,000,000 bond issue program on which we are now working. This new revenue really means more than another $60,000,000 bond issue. At least, it establishes the state highway building program on a sound financial basis and puts us in a position to advance our road building program to a point where we will build at least 1,000 miles of finished roads annually. We have now contracted for $25,000,000 of our $60,000,000 road bonds made available in 1922.

Missouri in the past has not had a very good reputation for roads, but present indications are that we will soon rank among the leading states of the Union in surfaced roads. We now have completed about 1,600 miles of paving and 1,800 miles of road ready for resurfacing. Another two years will enable us to connect the scattered sections and show a large mileage of through and connected highways. Our state is now maintaining 7,600 miles of the state system. Each road is numbered and marked.

The state is now rendering a service to the traveling public fully 100 per cent better than it did two years ago, on account of the roads that have been built and the maintenance work that has been made effective. Very truly yours,

B. H. PIEPMEIER,

Chief Engineer, Missouri State Highway Commission, Jefferson City, December 5, 1924.

COST OF ROADS "PER MILE" IS MISLEADING

By L. A. Boulay, Director, Ohio Department of Highways and Public Works, Columbus, Ohio

The comparison of road costs per mile means very little to thinking people, and in many instances gives absolutely unfair results, unless width, labor, prices, length of haul and the topography of the country are taken into consideration at the same time.

It is not fair to compare the cost of a 20-ft road, built that wide because traffic demands it, with the cost of a 16-ft.

road. Material prices, haul and the cost per square yard, may be exactly the same, but the 20-ft. road will cost 25 per cent more per mile, because there is 25 per cent more road.

It is not fair to compare the cost of grading per mile in one section where the ground is flat and no drainage structures are required with the cost per mile of roads in the hilly counties, where grading must be heavy and the cost of bridging large.

Neither is it fair to compare the cost of roads per mile in one section where prices of labor are high, with another section where labor prices are lower.

Nor is it fair to compare the cost per mile in one section where materials can be delivered on a siding along the road, with another section off the railroad where there may be a 15-mile haul.

All these things being facts immediately apparent to any sane person, it seems like a waste of time to argue about the cost per mile when the cost per square yard is the thing to be considered. This is the way engineers would compare costs in order to get a true and fair comparison and can easily be understood by the average layman. Then if we want the cost per mile, let us figure the cost based on equal widths one mile long, and using the cost per square yard to obtain these results.

HOW SHORTENING HIGHWAYS SAVES MONEY

William H. Connell, Engineering Executive of the Pennsylvania Department of Highways, recently said that relocations on the Pennsylvania state highway system thus far have resulted in shortening through routes approximately 100 miles. With an average traffic of 1,000 vehicles a day the saving in operation costs approximates $4,430,000 per year.

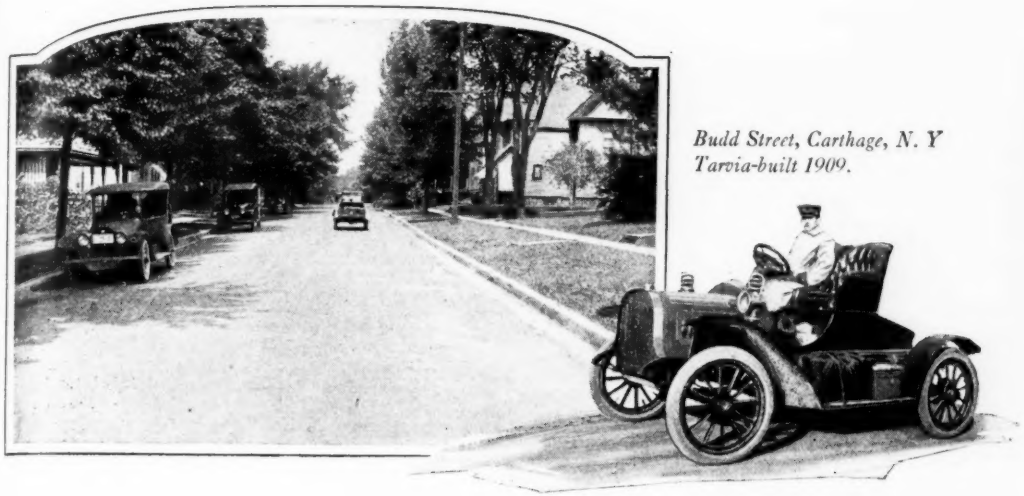
"It is particularly important," said Mr. Connell, "that through routes should be located with a view to carrying traffic to and from the different centers of population by the shortest possible route and over roads having reasonable grades and curves. When roads were laid out for local horse-drawn traffic not much attention was given to selecting the short route. The old highways, as a rule, are not economically located.

"Sometimes it has been found necessary by the Highway Department to eliminate minor centers of population where it would increase the distance considerably to pass through these communities. The economic necessity of providing the logical shortest route sometimes leads to a sacrifice of local interest for the general good. In general in Pennsylvania the location of state highways is fixed by legislative enactments which name the principal points connected by the roads. Between these points the Highway Department has wide powers of relocation and uses them to establish locations which will best serve the greatest number. State highway routes are essentially through routes.

"The average motor transportation cost to highway users for each thousand feet over a hard surfaced road is approximately 2.3 cts. for each vehicle. For 1,000 motor vehicles, therefore, the cost would be $23 per day—$8,395 per year, or approximately $167,900 over a period of 20 years. The necessity of shortening the distance where practical is clearly indicated. The Department has made many relocations which have cut the distance over a mile. Based on the figures given the saving to road users through these relocations is approximately $44,300 per mile per year, or $886,000 over a period of 20 years.

"Our relocations approximate a saving of 100 miles. The saving and operating costs with an average traffic of 1,000 vehicles a day is approximately $4,430,000 per year. But to this must be added the average annual cost of 100 miles of pavement, the interest on the investment, sinking fund requirements for the bond issue and the maintenance cost, or $480,000. The total saving, therefore, accruing to the taxpayers through the 100-mile reduction in distance is $4,910,000 per year. In other words, if these relocations had not been made the faste or loss to the public would be $4,910,000.

"It is difficult for local communities to reconcile themselves to the routing of the highway around their community instead of through the main street, but when highways are built for through traffic the only sound policy is to build them in the location most economic for all the users. This, of course, refers to the main highways. The secondary highways—or feeders to the main highways, should travel through all of the smaller centers of population, similarly to the branch lines of the railroads, so that they can pick up the travel to the main lines of highways."



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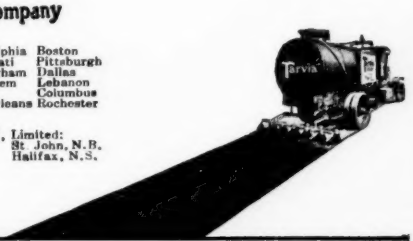
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